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January 10, 2020

Via email only

Richard Mruz, Project Manager
HMWMD B2
4300 Cherry Creek Drive South
Denver, CO 80246-1530
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RE: Denver Arapahoe Chemical Waste Processing Facility (DACWPF)
Comments on Draft Renewal Permit

Dear Richard:

I am hereby submitting comments on the above-referenced draft renewal permit on behalf of Waste Management of Colorado, Inc., the permittee.

A. Fact Sheet

1. The description of the Facility should be changed in the Fact Sheet to:
The facility has been in post-closure care for approximately thirty (30) years. This will be the second permit renewal.

The original permit was issued in 1999, and it was renewed once in 2009.

B. Permit Text

No comments.

C. Appendices A, B, C, D, and E

No comments.

D. Appendix F

1. The second paragraph in Section 2.3 should be changed as shown in **Exhibit A** to account for the addition of the new constituent – PFOA/PFOS – which are neither VOCs nor metals.

2. Steps 3 and 5 of Section 2.4 should be changed as shown in **Exhibit A** to delete the sampling reference in Step 3 (which is limited to well purging) and include the sampling reference in Step 5 (which explains sample handling).

E. Appendix G

1. The Action Limits for the existing Secondary Leachate Detection System Analytes should not be changed; and the Action Limit for the new indicator analyte – PFOA/PFOS – should be set no lower than 13.6 µg/L.

In the draft renewal permit, the list of Secondary Leachate Detection System Analytes and the Action Limits for those analytes (listed in Table G-1 of the draft renewal permit) have been changed from those contained in the current permit at Table A-8 as shown in the following Table 1:

Table 1

CONSTITUENT	ACTION LIMIT IN CURRENT PERMIT	ACTION LIMIT IN DRAFT RENEWAL PERMIT
Benzene	10.0	5.0
Carbon tetrachloride	50	5.0
Chlorobenzene	50	100
Chloroform	50	3.5
1,2 Dichloroethane	50	5.0
1,1 Dichloroethene	50	7.0
Methyl ethyl ketone	1,000	1,000
Tetrachloroethene	50	5.0
Trichloroethene	50	5.0
Vinyl Chloride	100	2.0
Arsenic	100	10
PFOA/PFOS*	NA	0.07

*New analyte

No technical justification was provided for the new (and generally lower) Action Limits proposed in the draft renewal permit for the existing analytes or for the extremely low Action Limit for PFOA/PFOS. As explained below: (a) the Action Limits in the current permit are highly conservative and protective of human health and the environment and should not be changed; and (b) the proposed Action Limit for PFOA/PFOS is overly conservative and should be changed to something comparable to the Action Limits in the current permit for the existing analytes.

a. Action Limits for existing analytes should **not** be changed.

The Risk Assessment supporting the delisting petition for the Reconstructed Cell leachate (Terra Technologies, January 30, 1998, attached hereto as **Exhibit B**) concluded that the proposed management option for that leachate (application for dust suppression at a Subtitle D facility) did not pose a risk to public health and the environment. In reaching that conclusion, the following exposure point concentrations (EPCs) were used in the risk calculations: "the maximum detected value [of the constituent] or ½ of the maximum detection limit [for that constituent], if no detections occurred." 1998 Risk Assessment at 5-6. Since arsenic had been detected at 110 µg/L, that was the EPC value that was used to assess the risk of the proposed management option for that constituent. And, since none of the VOCs had been detected at their respective detection levels, the EPCs for those constituents were set at ½ their maximum detection limits. For example, the maximum detection limit for benzene was 10 µg/L, and the EPC value used for assessing risk of the proposed management option for that constituent was 5 µg/L.

Those maximum detection limits were then used as the Action Limits for the VOCs in the original Part B permit issued in 1999 and the first renewal of that permit issued in 2009. The Action Limit in these permits for arsenic was rounded down from 110 µg/L (the maximum detected value) to 100 µg/L.

Subsequently, Terra Technologies developed risk-based screening levels (RBSLs) for the Secondary Leachate Detection System Analytes (as well as other constituents) to confirm that the management option authorized by the leachate delisting remained safe even if concentrations of the Secondary Leachate Detection System Analytes exceeded their respective EPCs and Action Limits (Terra Technologies, Updated RBSL Study, June 22, 2009 - attached hereto as **Exhibit C**). As shown in Table 2 below, the RBSLs for the original Secondary Leachate Detection System Analytes (excluding PFOA/PFOS for which there was no data in 1998 or 2008-9) are all significantly higher (about 11 to 42,736 times higher) than the current Action Limits for the existing Secondary Leachate Detection System Analytes.

Table 2

Indicator Parameter		Secondary Leachate Detection System Analyte Action Limits in Current Permit (µg/L)	Calculated RBSL in 2008-2009 Study (µg/L)	RBSL/Action Limit Factor
Benzene		10	1,600	160.00
Carbon tetrachloride		50	802	16.04
Chlorobenzene		50	279,000	5580.00
Chloroform		50	602	12.04
1,2 Dichloroethane		50	536	10.72
1,1 Dichloroethene		50	1,131,000	22620.00
Methyl ethyl ketone		1,000	42,736,000	42736.00
Tetrachloroethene		50	555	11.10
Trichloroethene		50	6,410	128.20
Vinyl Chloride		100	1,450	14.50
Arsenic		100	3,630	36.30

As demonstrated by the RBSL calculations, the Action Limits in the current permit are very conservative and, as such, there is no need to take any action as long as concentrations of these analytes in the secondary sump remain below their respective Action Limits. Nothing has changed that would justify a reduction of these Action Limits as is being proposed in the draft renewal permit (for all but two analytes – chlorobenzene and methyl ethyl ketone). This is especially true in this instance since the secondary sump leachate is pumped regularly to prevent any head build up, which essentially eliminates potential leachate/analyte migration from the secondary sump. As such, the Action Limits for the existing Secondary Leachate Detection System Analytes should not be changed in the final renewal permit.

Further support of the protectiveness of the current Action Limits for the secondary sump analytes is provided by Golder's Technical Memorandum on Dilution Factors and Travel Times attached hereto as **Exhibit D** ("Dilution Memo"). In that Dilution Memo, Golder calculates a flow rate, or flux, from the secondary sump, through the underlying claystone, to the Lower Sandstone Unit based on a number of conservative assumptions including the complete deterioration of the synthetic liner of the secondary sump (this very low permeability engineered component of the liner system is assumed absent). That flow rate (vertical seepage) is then compared to the calculated groundwater flux of the Lower Sandstone Unit which, although relatively small because of a flat gradient, is still two orders of magnitude higher than the flux from the secondary sump. As a result of these disparate flow rates, the Lower Sandstone Unit will dilute any analytes that theoretically could migrate from the secondary sump to the Lower Sandstone Unit by a factor of at least 181. As a result, the concentration of

any analyte that has been detected at its respective Action Limit in the secondary sump will be below the human health-based standard for that analyte when mixed in the Lower Sandstone Unit as shown in Table 3 below.

Table 3

Indicator Parameter	Secondary Leachate Detection System Analyte Action Limits in Current Permit (µg/L)	Action Limit divided by 181 (µg/L)	Health-Based Standard
Benzene	10	.06	5.0
Carbon tetrachloride	50	.28	5.0
Chlorobenzene	50	.28	100
Chloroform	50	.28	3.5
1,2 Dichloroethane	50	.28	5.0
1,1 Dichloroethene	50	.28	7.0
Methyl ethyl ketone	1,000	5.5	1,000
Tetrachloroethene	50	.28	5.0
Trichloroethene	50	.28	5.0
Vinyl Chloride	100	.55	2.0
Arsenic	100	.55	10

Stated another way, if any water in the Lower Sandstone Unit is ever consumed (an extremely unlikely scenario), the Action Limits in the current permit would be fully protective of that use.

b. Action Limit for PFOA/PFOS should be set no lower than 13.6 µg/L.

As for the Action Limit for the added Secondary Leachate Detection System Analyte – PFOA/PFOS – it should not be set at the EPA health advisory value of 70 ppt as is proposed in the draft renewal permit. That limit is overly restrictive and not technically justified since that health advisory is based on ingestion and no one will be drinking the secondary sump leachate. Further, as explained above, any PFOA/PFOS escaping the secondary sump will be diluted by a factor of at least 181 if it ever reaches the Lower Sandstone Unit.

Instead, the Action Limit for PFOA/PFOS should be set at a value that is comparable to the Action Limits in the current permit for the original analytes since, as explained above, those Action Limits are fully protective of public health and environment. A comparable Action Limit for PFOA/PFOS should be based on multiplying the RBSL for PFOA/PFOS times a factor that is reasonably comparable to the RBSL/Action Limit Factors shown in the last column of Table 2 above, such as the average (mean) or median of those factors.

Using assumptions similar to those used in its 2009 RBSL Study, Terra Technologies has calculated the RBSL for PFOA/PFOS as 88,300 µg/L. Terra Technologies 2019 (attached hereto as **Exhibit E**). Using the average (6,484) and the median (36.3) of the RBSL/Action Limit Factors shown in the last column of Table 2 above results in a range of reasonably comparable Action Limits for PFOA/PFOS from about 13.6 to 2,433 µg/L. There is simply no rational justification for setting the Action Limit for the new Secondary Leachate Detection System Analyte – PFOA/PFOS – any lower than 13.6 µg/L.

This 13.6 µg/L floor for the PFOA/PFOS Action Limit is further supported by the 181 dilution factor developed by Golder. If any PFOA/PFOS is detected in the secondary sump at an Action Limit of 13.6 µg/L and the secondary sump fails (vertical migration of these analytes was able to occur and reach groundwater within the Lower Sandstone), the concentration of PFOA/PFOS in the Lower Sandstone would be 13.6/181 = .075 or 75 ppt, which is basically the same as EPA's drinking water health advisory of 70 ppt.

2. The Action triggered by a confirmed detection in the secondary sump should be limited given the unique site characteristics of DACWPF.

In the current permit and the proposed renewal permit, the permittee is required to install 3 groundwater monitoring wells in the Upper Sandstone Unit and 3 groundwater monitoring wells in the Intermediate Sandstone Unit if there is a confirmed detection of a Secondary Leachate Detection System Analyte above its respective Action Limit.

Upon further review, there doesn't appear to be any technical basis for sampling the Upper and Intermediate Sandstone Units for the presence of reconstructed cell analytes from a "leaky" secondary sump. As noted Golder's Technical Memorandum on Recommendations for Monitoring Wells for DACWPF (attached hereto as **Exhibit F**), the Upper Sandstone Unit is located above the elevation of the bottom of the secondary sump.[1] And, the Intermediate Sandstone Unit is generally a low permeability, laterally discontinuous unit located below the Upper Sandstone, but the only known saturated zone within that unit lies at the very south edge of the reconstructed cell. It is virtually impossible for any leak from the secondary sump to travel laterally to that sandstone lens.

Simply put, installing groundwater monitoring wells into the Upper and Intermediate Sandstone Units and sampling whatever water might be intercepted by those wells, if any, will provide no meaningful information about the integrity of the secondary sump or the nature of a potential leachate release since wells installed in these units are incapable of providing information for

[1] Further, as the annual groundwater reports for DACWPF have demonstrated, the Upper Sandstone Unit appears to have been effectively dewatered by the perched water drain.

these purposes. Since the predominant flow path of a leachate release from the secondary sump would be downward through the underlying claystone, the Lower Sandstone is the optimal monitoring unit to determine a potential leachate release and its significance. Further, the time of travel for such flow is estimated by Golder to be over 3,000 years. Thus, even if the secondary sump had failed at the moment it was completed in the late 1980s, that failure would still not have impacted the Lower Sandstone Unit. Finally, Golder calculates that based on the groundwater gradient, hydraulic conductivity, and effective porosity of the Lower Sandstone, groundwater moves very slowly in this unit, on the order of only 0.0004 ft/day (*i.e.,* 0.15 feet per year, or 1.5 feet every 10 years). At this rate, there would be ample time to address any analyte detections of concern prior to affected groundwater potentially migrating offsite toward possible receptors since the DACWPF property line is over 100 feet downgradient of the Lower Sandstone detection monitoring wells. Therefore, monitoring only the Lower Sandstone is protective of human health and the environment and represents the best action if confirmed Action Limits are exceeded in the secondary sump.

In light of this re-evaluation, the "Action" that is triggered by a confirmed detection of a Secondary Leachate Detection System Analyte above its respective Action Limit should be limited to the following modified Step 2 of Section 4.0 in Appendix G of the proposed renewal permit:

> *Step 2: If detection of an analyte above its respective trigger limit listed in Table G-1 is confirmed in the secondary sump leachate in Step 1, the Permittee will use reasonable efforts to identify and remedy the cause of the detection and will, within sixty (60) days after confirmation submit a report to the CDPHE for review and approval which:*
>
> *a. Contains the results of the field and laboratory analyses performed;*
>
> *b. Discusses the analytical results;*
>
> *c. Summarizes the efforts in identifying and remedying the cause of the detection; and*
>
> *d. Presents a plan for further work and monitoring (as and if necessary) together with any necessary permit modification requests for implementing such further work, to further identify and remedy the cause of the detection and/or to determine if the effectiveness or integrity of the reconstructed cell have been compromised.*

Any action beyond this would be unreasonable and technically unjustified because it would essentially prejudge the cause of the confirmed detection which, at this time, is completely unknown and unknowable.

There are three additional site-specific facts that justify the limited actions described above. First, as noted above, the leachate is pumped regularly to prevent any head build up in the secondary sump which essentially eliminates the potential for any leakage from the secondary

sump to migrate downward should it be compromised. Second, as noted by Golder, the Lower Sandstone Unit has the capacity to significantly dilute any secondary sump contaminants that might reach that formation. And third, 20 years of data collection have demonstrated that the Lower Sandstone Unit has a nominal hydraulic gradient toward the northwest. Taken together, these site-specific facts ensure that there will be plenty of time to address any leakage from the secondary sump that might complete its 41 foot downward travel to the Lower Sandstone Unit and have a measurable effect on the chemistry of the water in that unit. This limited action is fully protective of public health and the environment.

Changes to Appendix G that implement the changes described above are shown on **Exhibit G** attached hereto.

Respectfully,

Tom Schweitzer, P.E.
Senior Engineer
Waste Management of Colorado, Inc.

Enclosures

cc: Mr. Steve Richtel, Environmental Legacy Management Group – Waste Management
Mr. Louis Bull, Groundwater Protection – Waste Management
Ms. Catherine Riegle-Finley, Legal Counsel – Waste Management
Mr. Gene Riordan, Vranesh and Raisch

1.0 POINT OF COMPLIANCE

The point of compliance for post-closure groundwater monitoring is the vertical plane located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer (6 CCR 1007-3, Section 264.95). In this case, the waste management area is defined as that area projected in the horizontal plane on which waste was placed into and on which liners and caps were constructed for the reconstructed cell. Thus, the designated point of compliance for the reconstructed cell is just downgradient of the reconstructed cell. See Figure 8.

2.0 DETECTION MONITORING PROGRAM

2.1 General

The purpose of detection monitoring is to detect the release of hazardous waste constituents from the reconstructed cell at the designated point of compliance, should any release occur. The elements of the detection monitoring program include the groundwater monitoring wells, indicator parameters, and background and detection monitoring.

2.2 Groundwater Monitoring Wells

The groundwater monitoring well network for post-closure care detection monitoring is designed to detect releases of contamination in the uppermost aquifer at the designated point of compliance and to assess the direction of groundwater flow in the vicinity of the reconstructed cell. Six groundwater monitoring wells (P-112, P-113, P-114, P-114A, P-114A-R, and P-115) have been used to date. Four groundwater monitoring wells are currently used, and will continue to be used, to collect groundwater samples, since P-114A-R has replaced P-114 and P-114A. Well P-112 is the designated upgradient monitoring well, whereas the other three wells are the designated downgradient wells. However, due to the documented spatial variability of the groundwater, detection monitoring is based on intra-well comparisons (i.e., the data from each well is compared to the background value for that well).

The spacing of the downgradient monitoring wells located in the lower sandstone unit was based on the hydrogeologic characterization conducted by Golder. A channel sand was encountered (lower sandstone) at approximately 80 feet below ground surface. Wells were positioned in this channel sand located beneath the reconstructed cell for monitoring the entire width, including the fringes, on the

downgradient side of the reconstructed cell. Well P-114A-R is (and P-114 and P-114A formerly were) located in the center of the channel sand, while P-113 and P-115 are located on the fringes of the channel.

All monitoring wells were completed, and will be maintained, to ASTM Standard Guide D5092-04, "Standard Practice for Design and Installation of Ground Water Monitoring Wells." Additionally, all of these wells are designated as RCRA monitoring points and, as such, were designed to comply with 6 CCR 1007-3, Part 264, Subpart F.

Any wells deleted from the monitoring program must be plugged and abandoned in accordance with ASTM D5092-04. Well plugging and abandonment methods and certification will be submitted to the Director, or designee, within one hundred twenty (120) days from the date the wells are removed from the monitoring program.

2.3 Detection Monitoring Indicator Parameters

Detection groundwater monitoring requires a suite of parameters be established for analyses that provide a reliable indication of the presence of hazardous constituents in groundwater. The parameters selected should be the most accurate and reliable indicators of the leading edge of contamination and should provide minimal false positive and false negative statistical results.

The constituents (and their respective reporting limits) listed in the following Table F-1 ~~Volatile organic compounds (VOCs) and eight metals~~ will be used as indicator parameters of groundwater contamination during post-closure care detection monitoring~~. The VOCs and metals, and their respective reporting limits, are listed in the following Table F-1~~:

TABLE F-1

GROUNDWATER INDICATOR PARAMETER AND WASTE CONSTITUENT LIST
("Reporting Limits" are in µg/L = micrograms per liter)

CONSTITUENT	REPORTING LIMIT
pH, Temperature, Conductivity	NA
Total Suspended Solids	NA
Benzene	5.0
Bromoform	4.0
Carbon Tetrachloride	1.0
Chlorobenzene	5.0
Chlorodibromomethane	5.0

CONSTITUENT	REPORTING LIMIT
Chloroethane	10.0
Chloroform	3.5
Dichlorobromoethane aka (Bromodichloromethane)	1.0
1,1-Dichloroethane	5.0
1,2-Dichloroethane	1.0
1,1- Dichloroethylene aka (Dichloroethene)	5.0
1,2-Dichloropropane	1.0
cis-1,3-Dichloropropylene aka (Dichloropropene)	5.0
Ethylbenzene	5.0
Methyl bromide aka (Bromomethane)	10.0
Methyl chloride aka (Chloromethane)	10.0
Methyl ethyl ketone*	100.0
1,1,2,2-Tetrachloroethane	5.0
Tetrachloroethylene aka (Tetrachloroethene), (Perchloroethene)	5.0
Toluene	5.0
1,2-Trans-dichloroethene	10.0
1,1,1-Trichloroethane	5.0
1,1,2-Trichloroethane	3.0
Trichloroethylene aka (Trichloroethene)	5.0
Vinyl Chloride	2.0
PFOA/PFOS**	0.01
Arsenic	10.0
Barium	200.0
Cadmium	5.0
Chromium (Total)	10.0
Lead	5.0
Mercury	0.2
Selenium	5.0
Silver	25.0

*Only to be analyzed if leachate in secondary sump exceeds the detection limit in Table G-1
**Only to be analyzed if leachate in secondary sump exceeds the action limit in Table G-1

2.4 Groundwater Sampling

All sampling will be conducted pursuant to ASTM protocol or equivalent. The following steps will be performed for detection groundwater monitoring:

Step 1. Inspection. Prior to purging or sampling, each monitoring point will be inspected. The condition of the sampling equipment and the well structure which could affect the collection system will be noted.

Step 2. Static Water Level Measurement. Prior to purging, the static water level will be measured and recorded until reproducible results are obtained. The static water level will be measured as the depth to water in the well from the top of the casing and will be recorded to the nearest 0.01 foot. Water level probes, which were calibrated when the wells were installed and need no additional calibration, will be inspected for damage prior to each sampling event.

Step 3. Well Purging. Monitoring wells will be purged prior to sample collection in order to obtain representative samples of the formation water rather than the stagnant water from the well casing. ~~Sampling will be performed consistent with ASTM D4448-01 – "Standard Guide for Sampling Ground-water Monitoring Wells" or equivalent. Sampling for PFOA/PFOS will be conducted in general accordance with the February 8, 2019 Groundwater Screening Proposal, if required.~~ Purging completion is based on achieving stabilization of the water level within the well and water quality field indicator parameters measured during purging. Pump flow rates should be selected to approximate the yield of the well so that a stabilized pumping water level is achieved as quickly as practical, thus expediting the stabilization of the field indicator parameters. Field indicator parameter measurements should be initiated when purging begins and continued at regular intervals until stabilization is achieved. Purged water will be stored in 35-gallon or 55-gallon drums and disposed of appropriately following review of the laboratory analytical results.

Step 4. Sample Withdrawal. Once stabilization has been achieved during purging, sampling can be conducted at the same pumping rate or at a lower flow rate if desired. If a sufficient amount of water is unobtainable for all analyses, the priority of analysis will be VOCs first and then metals. If a sufficient amount of water is unobtainable for any analysis, the well will be considered dry, and the Permittee will not be considered out of compliance for that sampling event.

Step 5. Sample Handling. Samples for VOCs will be unfiltered and unpreserved in accordance with Colorado requirements. Samples for metals will have the appropriate acid preservative added in the field and will be filtered through a 0.45 micron membrane filter prior to preservation. All bottles will be pre-labeled and supplied by a pre-approved laboratory. The VOC sample bottles will be 40 ml glass bottles which contain Teflon-lined septums in the cap. Each bottle will be filled slightly more than full prior to being capped to ensure that no head space exists once the bottle is capped. Sampling will be performed consistent with ASTM D4448-01 – "Standard Guide for Sampling

Ground-water Monitoring Wells" or equivalent. Sampling for PFOA/PFOS will be conducted in general accordance with the February 8, 2019 Groundwater Screening Proposal, if required. Immediately after sample collection, bottles will be placed in sealed, insulated shuttles, and packed with ice to cool the samples to a temperature of 4°C or less. The shuttles will be shipped to the laboratory for arrival within 72 hours.

Step 6. Chain-of-Custody Procedures. The following chain-of-custody program will be used to trace the possession and handling of the individual samples. Samples from the same sample point that are placed in more than one sample cooler require a Chain-of-Custody Record in each sample cooler. Any problems with the sample cooler's contents will also be noted on the form. Upon receipt of the sample cooler by the lab, the condition of the samples, temperature, date, and time will be recorded on the Field Chain-of-Custody Record by the log-in personnel receiving the sample coolers. The Field Chain-of-Custody Record indicates by bottle and analysis group whether samples are preserved. The sampling team must record the field filtration, preservative, and any deviations from normal preservation requirements on the Chain-of-Custody Record (the sampler will initial the forms if this information is preprinted on forms provided by the lab). Other Chain-of-Custody procedures are described in Section 2.6.

2.5 Laboratory Analytical Procedures

The laboratories approved for the detection groundwater monitoring program will use approved standard laboratory procedures as specified in EPA's Test Methods for Evaluating Solid Waste: Physical/Chemical Methods SW-846 2nd Edition, Standard Methods of Wastewater Analysis, or an equivalent method approved by the Department. TestAmerica Laboratories Inc. in Arvada, Colorado or a similar environmental laboratory will perform chemical analysis of the groundwater. The particular SW-846 test methods will be as follows:

CONSTITUENT	EPA SW-846 TEST METHOD
VOCs	8260B
Arsenic, Barium, Cadmium, Chromium (total), Lead, Silver, Selenium	6010B
Mercury	7470A
PFOA/PFOS*	537 Modified until 8328 is finalized

* To be analyzed if leachate in secondary sump is above action limit listed in Table G-1

2.6 QA/QC

Quality Assurance and Quality Control (QA/QC) procedures will be applied to both field and analytical laboratory data in order to ensure the reliability and validity of the data. The QA/QC procedures are described below.

Field blank samples will not be required if each of the wells sampled has dedicated sampling equipment. If dedicated sampling equipment is not used, one field blank sample will be taken for every ten groundwater samples collected or one per day during each sampling event, whichever is greater, to detect contamination that may be introduced: (1) in the field (either atmospheric or from specific sampling equipment); (2) in transit to or from the sampling site; (3) in sample container preparation, sample log-in, or sample storage stages within the laboratory; or (4) during sample processing and analysis within the confines of the laboratory. A complete set of sample containers will be supplied by the laboratory and reagent-free deionized water will be used for the preparation of blank samples. Groundwater sampling procedures will be simulated for the filling of field blank samples. The filled sample bottles will be packed with ice and shipped to the laboratory for analysis along with the groundwater samples.

One QA duplicate will be collected for every twelve groundwater samples collected or one during each sampling event, whichever is more frequent, to be used as a check on the precision of sampling and analytical procedures. During a sampling sequence, a blind duplicate sample will be taken from the selected monitoring well(s) simultaneously with the regular field sample and analyzed along with all samples. During subsequent sampling rounds, different well(s) will be selected and the same procedures will be used to obtain the duplicate(s).

The chain-of-custody record will be initiated at the time of sampling and will contain the well number, date and time of sampling, and the name of the sampler. This record will accompany each sample case and will be signed by all who handle sample containers. Sample transfers are noted on the record sheet for each sample. Upon receipt of samples at the laboratory, the shipping container will be examined, and the condition of samples, including temperature, will be recorded. The chain-of-custody procedures document sample transfer, sample possession, and sample integrity from collection through analysis. If samples are split and sent to multiple laboratories, a chain-of-custody record sheet will

accompany each sample. Copies of chain-of-custody forms will be maintained at the laboratory conducting the analyses.

In addition, all laboratories will be required to maintain appropriate levels of quality control for all analyses performed.

2.7 Background Monitoring

A. VOCs

No VOCs have had a confirmed detection since interim status quarterly groundwater monitoring for VOCs began in 1990. As a result, the "background" value for each of the VOCs is set at the "reporting limit" ("RL") listed in Table F-1. The permit-required RL for each VOC listed in Table F-1 must be achieved when analyzing the samples.

B. Metals

The background values for metals are the control limits and non-parametric prediction limits computed using the procedures outlined in the prior permit. The current values are as follows:

Constituent	Units	Well	Background Value
Arsenic, total recoverable	UG/L	P-112	10.0000*
Arsenic, total recoverable	UG/L	P-113	10.0000*
Arsenic, total recoverable	UG/L	P-114A	10.0000*
Arsenic, total recoverable	UG/L	P-115	10.0000*
Barium, total recoverable	UG/L	P-112	27.4055
Barium, total recoverable	UG/L	P-113	22.9172
Barium, total recoverable	UG/L	P-114A	43.2311
Barium, total recoverable	UG/L	P-115	19.8164
Cadmium, total recoverable	UG/L	P-112	5.0000*
Cadmium, total recoverable	UG/L	P-113	5.0000*
Cadmium, total recoverable	UG/L	P-114A	5.0000*
Cadmium, total recoverable	UG/L	P-115	5.0000*
Chromium, total recoverable	UG/L	P-112	10.0000*
Chromium, total recoverable	UG/L	P-113	10.0000*
Chromium, total recoverable	UG/L	P-114A	14.1000*
Chromium, total recoverable	UG/L	P-115	10.0000*

Constituent	Units	Well	Background Value
Lead, total recoverable	UG/L	P-112	5.0000*
Lead, total recoverable	UG/L	P-113	5.0000*
Lead, total recoverable	UG/L	P-114A	5.0000*
Lead, total recoverable	UG/L	P-115	5.0000*
Mercury, total	UG/L	P-112	0.2000*
Mercury, total	UG/L	P-113	0.2000*
Mercury, total	UG/L	P-114A	0.2000*
Mercury, total	UG/L	P-115	0.2000*
Selenium, total recoverable	UG/L	P-112	5.0000*
Selenium, total recoverable	UG/L	P-113	5.0000*
Selenium, total recoverable	UG/L	P-114A	5.0000*
Selenium, total recoverable	UG/L	P-115	5.0000*
Silver, total recoverable	UG/L	P-112	25.0000*
Silver, total recoverable	UG/L	P-113	25.0000*
Silver, total recoverable	UG/L	P-114A	25.0000*
Silver, total recoverable	UG/L	P-115	25.0000*

*Detection Frequency < 25%

These background values will be updated every other year using the additional data from the four most recent semi-annual monitoring events.

C. Others

No background values have been, or will be, calculated for field parameters pH, temperature, conductivity, or TSS because these parameters will not be subject to statistical analysis.

2.8 Detection Monitoring

Detection monitoring for VOCs began in 2000. Detection monitoring of metals began in 2003--six months after the completion of the background monitoring for metals. Detection monitoring will continue semi-annually through the post-closure care period or unless compliance or corrective action groundwater monitoring programs are established.

Due to the documented spatial variability of the natural groundwater chemistry, intra-well comparisons (i.e., the data from each well is compared to its own background history) will be the basis for determining if there is a statistically significant increase above background. For informational purposes, a comparison of the designated upgradient well chemistry to the designated downgradient wells chemistry will also be provided.

The actual process for detection monitoring will proceed in accordance with the following steps:

Step 1. Sample monitoring points semi-annually. The sampling points will be monitored for the indicator parameters listed in Table F-1, as well as for groundwater hydraulic information to establish flow rates and direction.

Step 2. Review QA/QC data to verify that acceptable field and laboratory data have been generated and recorded. If data is unsatisfactory, a Quality Assurance Review (QAR) will be performed and the affected well(s) resampled, if appropriate, within forty-five (45) calendar days of receipt of the sampling event data from the laboratory. If the data is satisfactory, the process will proceed to Step 3.

Step 3. Evaluate the sampling results by comparing the current sampling data for each well to the background value for that well. In the event the current sampling data exceeds the background values, verification resampling will occur by collecting up to two (2) additional samples to determine if the initial exceedance is statistically significant above background. If the first additional sample is below the background value, the initial exceedance is not verified and the well remains in detection monitoring. If the first and second additional samples are above the background value, the initial exceedance is verified and is determined to be statistically significant (i.e., represents a statistically significant increase above background – SSI).

Step 4. Identify SSIs, of any parameter. Also, for informational purposes, compare the current sampling data for the designated upgradient well to the designated downgradient wells. These evaluations will be performed within 45 days after receipt of final laboratory results for the sampling event including any additional samples required by Step 3.

Step 5. If the results from Step 3 show that no SSI has occurred, the detection monitoring program will continue, beginning again with Step 1 and the results will be reported annually. After four semi-annual samples, the background values for the metals will be updated using the additional data.

Step 6. If the results from Step 3 show that an SSI has occurred, the Department will be notified in writing within seven (7) days of the findings in Step 3 in accordance with 6 CCR 1007-3 Section 264.98 (g)(1) along with the Permittee's intentions with regard to a source demonstration pursuant to the requirements of 6 CCR 100 7-3 Section 264.98(g)(6).

Step 7. If the results of Step 3 show an SSI has occurred and a source demonstration is not going to be conducted, the groundwater in all of the monitoring wells will be sampled and analyzed for 6 CCR 1007-3, Part 264, Appendix IX constituents within one month following the results of the additional sampling described in Step 3.

Step 8. Within ninety (90) days following determination of an SSI, an application for permit modification will be submitted to the Director, or designee, for changes to the detection monitoring program, implementation of a compliance monitoring program, or a permit modification application for a variance; and/or the source demonstration report will be submitted.

In addition to the notification requirements for an SSI, the Permittee will submit annual reports detailing the procedures, results, and statistical evaluations from the detection monitoring. All annual reports will be submitted no later than 45 working days after receiving the laboratory analytical results from the last sampling event within the reporting period.

All of the piezometric head information obtained from the RCRA groundwater monitoring wells will be reported along with the water quality data on an annual basis. The water level data will also be plotted for each water level measurement event and submitted with the annual report. This information will not be subjected to any statistical analysis. It will, however, be used to evaluate upgradient and downgradient conditions.

2.9 Data Management

The results of the field and laboratory analyses performed on groundwater samples will be recorded for each sampling point and sampling event. The records will include the following information:

- Well identification and date of analysis;
- Analytical results for all required sample parameters, as well as results for QA/QC duplicates and test blanks;
- Field data (including temperature, pH, specific conductance, and water level);

- Description of analytical procedures and QA/QC protocol;
- Chain-of-custody forms;
- Summary of all computations (including example calculations; data for each of the calculations; each measured, known, or estimated value so that each calculation may be verified by the Director, or designee) required by this Permit to calculate background concentrations and to determine if there has been a statistically significant increase above background (SSI); and
- Contaminant concentration maps including annotated values associated with each monitoring point, if contaminants above background are detected.

Laboratory data will be presented in tabular and/or graphic form. In addition, copies of the laboratory analysis and field (inspection) data sheets for the reporting period will be included in the annual report. All raw analytical data will be stored by the analytical laboratory or the Permittee.

2.10 Data Confirmation Review

Initial evaluation of groundwater analytical data will entail data confirmation through QA/QC review. The first step will be a thorough review of lab and field procedures, including review of field equipment calibration information, recoveries of spiked samples, and field blank analyses. In addition, a detailed review of the chain-of-custody records for sampling, shipping, and preparation of the samples will be performed. A QAR will be filed to determine if suspect data are the result of a mathematical error, a lab artifact, other lab errors, or a shipping/sampling problem should the initial cursory review prove to be ineffective or inconclusive. At this stage of the groundwater data evaluation, data will be corrected if shown to result from a calculation error or a data transcription error. Laboratory artifacts will be addressed individually.

2.11 Permit Modification/Source Demonstration

If an SSI is determined, the Permittee will invoke its option to submit a permit modification or implement a source demonstration investigation.

3.0 COMPLIANCE MONITORING

Data collected since background monitoring at the reconstructed cell facility was completed establish that there has been no SSI of any of the indicator parameters at any of the RCRA groundwater monitoring wells. Therefore, pursuant to 6 CCR 1007-3, Section 100.41(c)(7), a compliance

monitoring program is not required. If a SSI for any parameter at any of the RCRA groundwater monitoring wells is determined during detection monitoring, the Permittee will submit a permit modification application to establish a compliance monitoring program.

4.0 CORRECTIVE ACTION

A program for corrective action is not required pursuant to 6 CCR 1007-3, Sections 100.41 and 264.100, since there has been no SSI for any of the indicator parameters at any of the RCRA groundwater monitoring wells. Should a corrective action program be required in the future, the Permittee will submit a permit modification application to establish such a program.

EXHIBIT B

Risk Assessment for Reconstructed Cell Sump Leachate for the Denver Arapahoe Chemical Waste Processing Facility

Prepared for
Waste Management of Colorado, Inc.

January 30, 1998

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APPENDICES

1.0 Introduction

A risk assessment was prepared to address a proposed management option for the reconstructed cell sump leachate at the Denver-Arapahoe Chemical Waste Processing Facility (DACWPF) in Arapahoe County, Colorado. The proposed management option is to use the leachate for dust control at various Subtitle D landfills.

The objectives of the risk assessment are as follows:

- to determine potential human health risks based on management of the leachate, and
- to determine potential ecological health risks based on management of the leachate.

The risk assessment is structured in accordance with current Colorado Department of Public Health and Environment (CDPHE) guidance, and other appropriate guidance including, but not limited to:

- CDPHE, 1994. Final Policy and Guidance on Risk Assessments for Corrective Action at RCRA Facilities,
- U.S. Environmental Protection Agency (EPA), 1989. Risk Assessment Guidance for Superfund, Volumes I and II.
- EPA, 1992. Framework for Ecological Risk Assessment.

The risk assessment is composed of several sections. The Exposure Assessment for human health, and the Exposure Analysis for ecological health, include a conceptual site model, which is a flow diagram of the exposure scenarios. Receptors are identified in these sections. The exposure pathways for each receptor, and the exposure point concentrations for each contaminant of potential concern (COPC), are also evaluated in these sections.

The Toxicity Assessment for human health contains a summary table of all appropriate carcinogenic and noncarcinogenic toxicity values from the EPA IRIS database (EPA, 1997) or Health Effects Assessment Tables (HEAST) (EPA, 1994a). The Toxicity Analysis for ecological health includes the toxicity values for aquatic life (Ambient Water Quality Criteria) and terrestrial life (Toxicity Benchmark Values). Quantitative risk assessment was performed on all analytes except iron, which is a macronutrient, and silica.

The Risk Characterization section quantifies the risks by drawing on the results of the previous two sections. Uncertainties in the risk assessment are discussed.

1.1 History of the Reconstructed Cell

The DACWPF reconstructed cell contains a double composite liner system that meets the RCRA minimum technology standards of Section 3004 (o) and 3015 of the Hazardous and Solid Waste Amendment (HSWA) of November 8, 1984 and subsequent EPA guidance documents available as of March, 1987 (Golder Associates, 1996). The cell is approximately 6 to 8 acres in size, and was constructed in two phases that began in July, 1987 and ended in July, 1988. Waste backfilling into the cell was completed in November, 1988, and a two-foot thick layer of clay was placed over the backfilled waste. Completion of the final cover occurred in October, 1989 (Golder Associates, 1996).

Water has collected in the reconstructed cell in part due to precipitation events that occurred during the 3 month period of waste backfilling during Phase II (Golder Associates, 1996). The precipitation events generated approximately 122,000 gallons of water over the exposed area of the reconstructed cell. Precipitation that fell within the cell boundary either infiltrated into the drainage layer of the floor or side-slopes, or was collected within temporary internal clay lined sumps located over the waste material (Golder Associates, 1996). Site records indicate that 37,750 gallons of water were pumped from the reconstructed cell into Pond 3 during the solidification operations, leaving about 84,000 gallons that could have potentially infiltrated into the primary leachate collection layer.

The primary source of water in the secondary leachate collection system is due to consolidation or settlement of the 18 inch thick clay layer (Golder Associates, 1996). Precipitation that occurred during construction of the secondary geomembrane liner and overlying drainage net may also have contributed slightly; however, most of this water was pumped out prior to placement of the overlying primary geomembrane liner. Settlement of the primary clay layer by only 0.1 inches could generate 5,900 gallons of water into the secondary leachate collection system if the clay layer was fully saturated (Golder Associates, 1996).

Estimates indicate that 48,000 gallons of water have been removed from the primary sump in the 9+ year period following placement of the final cover in November, 1988. Approximately 36,000 gallons of water remain in the primary leachate collection system, which will require pumping for an additional 14 to 20 years (Golder Associates, 1996). Water may continue to seep from the primary clay layer into the secondary leachate collection system in an ever-decreasing rate for the next 20 years as well.

Currently, Waste Management of Colorado, Inc. (WMC) is seeking to delist the reconstructed cell leachate collecting in the primary and secondary sumps. This risk assessment evaluates the potential risks associated with management of the reconstructed cell sump leachate.

1.2 Description of Management Option

The proposed management option is to use the leachate as a substitute water supply for dust suppression at Subtitle D facilities. Risk due to future residential exposure to soils to which the leachate is applied, or potential worker contact with the leachate during application, was considered in evaluating this option. Although the residential exposure scenario is evaluated in this risk assessment as required under CDPHE guidance, this exposure scenario is highly conservative since residential use of a Subtitle D facility is unlikely. The worker exposure scenario is also highly conservative, since workers are required to follow current U.S. Occupational Safety and Health Administration (OSHA) regulations, and to wear appropriate protective equipment. Ecological risks may occur due to contact with the soils after the leachate has been applied, and these risks are also addressed in the risk assessment.

1.3 Summary Statistics for Leachate Analytical Data

Appendix 1 presents the raw data for all analytes in the leachate. These include inorganics and pesticides, volatiles, and semivolatiles. None of the organics were detected in the leachate; however, risk calculations were performed in order to document that the detection limits of the sampling were adequate for assessment of health-based risks.

Table 1 presents the summary statistics for the data. All values below the detection limit were divided by 2 prior to calculating summary statistics in order to utilize all of the data without arbitrarily biasing the data set. This is consistent with current EPA practice (EPA, 1989).

2.0 Human Health Risk Assessment

2.1 Exposure Assessment

The Exposure Assessment quantifies the daily chemical intake by various exposure pathways for humans that could contact the reconstructed cell sump leachate consistent with CDPHE (1994) requirements that require that the site must meet unrestricted use, and which state:

- residential pathways must be considered,
- direct exposure (i.e., ingestion of soils) on or in the source must be considered,
- children must be considered as a sensitive subpopulation, and
- no dilution or attenuation may be incorporated into the equations.

Figure 1 is the Conceptual Site Model which outlines each of the potential exposure pathways resulting from management of the reconstructed cell sump leachate. Three human receptors may ultimately contact the leachate: workers who manage the leachate; and children and adults who may be residents as part of a conservative, hypothetical, future use of the property where the leachate has been applied. After application to soils, the leachate may infiltrate, run off the surface, or dry and potentially result in fugitive dust emissions. These transport mechanisms potentially allow the leachate to enter ground water, air, and soil. If the leachate infiltrates, ground water becomes a potential exposure media. Air and soil are potential current and future exposure media for leachate that dries on the soil surface. If the leachate runs off of the surface to nearby surface water onsite, or ponds on the soil surface, it may be contacted by workers moving equipment.

The daily chemical intakes in milligrams per kilogram body weight per day (mg/kg/d) are estimated for soil ingestion, leachate ingestion, dermal contact with soils or the leachate, and inhalation of soil particulates according to standard risk assessment equations (EPA, 1989; CDPHE, 1994). The parameters, abbreviations, and units used in each equation for each receptor are defined in Table 2. The equations are as follows:

Soil Ingestion (CDPHE, 1994):

$$Intake = \frac{Csoil \times IR \times EF \times ED \times CF}{BW \times AT} \qquad (1)$$

Dermal Contact with Soils (CDPHE, 1994):

$$Intake = \frac{Csoil \times SA \times AB \times AF \times EF \times ED \times CF}{BW \times AT} \quad (2)$$

Inhalation of Particulates (CDPHE, 1994):

$$Intake = \frac{Csoil \times CF \times INH \times ET \times EF \times ED}{PEF \times BW \times AT} \quad (3)$$

Leachate Ingestion (EPA, 1989):

$$Intake = \frac{C_{leachate} \times CR \times ET \times EF \times ED}{BW \times AT} \quad (4)$$

Dermal Contact with Leachate (EPA, 1989):

$$Intake = \frac{C_{leachate} \times SA \times PC \times ET \times EF \times ED \times CFw}{BW \times AT} \quad (5)$$

Each of the intake equations requires identification of an Exposure Point Concentration (EPC), or the concentration of each chemical at the point of contact by the receptor. The EPC is the maximum detected value according to the State corrective action program (CDPHE, 1994). EPA allows the use of statistical considerations in that the lower of the values for the maximum or the Upper 95th Confidence Limit (UCL95) is used as the EPC (EPA, 1989).

There is an EPC for each analyte in the leachate based on the analytical data (Table 3). The EPC is used as the concentration term in the above equations (C_{soil} or $C_{leachate}$). The EPC for leachate is the maximum detected value or ½ the maximum detection limit, if no detections occurred. The EPC for each analyte in the soil was based on the EPC for the leachate, and was estimated

by determining the total amount of each contaminant in the remaining volume of cell sump leachate as follows:

$$C_{leachate}(\frac{mg}{L}) \times \quad 36{,}000\,(gal) \quad \times \quad 3.785\,(\frac{L}{gal}) = Amount\,(mg) \tag{6}$$

An acre of soil to a depth of 15 cm weighs about 2 million lbs (Korschgen, 1971), or 907,200 kg/ac. Other estimates are that an acre-foot (0.4 ha * 30 cm deep) of mineral soil weighs 3-4 million lbs, dry (Brady, 1974). By dividing by 2 to adjust the soil layer to only 15 cm deep, and solving for hectares produces 4,375,000 lbs/ha; solving for acres yields 1,770,538 lb/ac or 803,116.1 kg/ac. Assuming that the leachate would be applied to an area of 10 acres when used for dust control (i.e., multiply the total kilograms per acre by 10), the amount of each analyte divided by the total mass of soil results in very low estimated soil concentrations (Table 3). The lower of the two estimates of soil mass (8,031,161 kg/10 ac) was used to obtain estimated soil concentrations in order to be conservative. No loss of volatiles or semi-volatiles due to vaporization was assumed in order to be conservative.

Because the period over which exposure is averaged, the averaging time (AT), differs for estimation of carcinogenic versus noncarcinogenic risk, intakes are also different. Table 3 presents the intakes estimated to obtain both carcinogenic and noncarcinogenic risk in the risk characterization. Other conservative assumptions included the use of the highest permeability coefficient (PC) to obtain estimates of dermal uptake of inorganics for worker contact with leachate. When available, PC values specific to the organics in question were used since the PC values for organics spanned more than 2 orders of magnitude.

2.2 Toxicity Assessment

The Integrated Risk Information Service (IRIS) was searched to obtain current information on the toxicity values used to determine noncarcinogenic and carcinogenic risk (EPA, 1997). HEAST (EPA, 1994a) was also reviewed to obtain toxicity values for human health. The values in HEAST are proposed and not final. Noncarcinogenic risk is defined with a reference dose (RfD), while risks due to cancer are defined with a slope factor (SF) (Table 4). The slope factor for vinyl chloride is a proposed value from HEAST. All other toxicity values are from IRIS.

Noncancer risk can be defined for most of the inorganics detected in the leachate. The toxicity of cadmium differs depending on whether it is administered to laboratory test animals in diet or in

water. This results in different RfDs for water ingestion compared to other oral ingestion pathways (Table 4). Therefore, risks due to oral exposure directly to leachate for cadmium were addressed with the more conservative RfD for water (Table 4). The standard oral RfD for cadmium was used to evaluate dermal risks. Iron was not evaluated, as this element is a macronutrient; in addition, toxicity values are lacking for iron. Silica also was not evaluated, as toxicity values are lacking. Toxicity values are lacking for lead, as risk due to exposure to lead is quantified on the basis of blood lead concentrations. EPA has recommended a soil lead criterion protective of human health of 400 mg/kg (EPA, 1994b).

Of the inorganics, only arsenic has carcinogenic effects due to oral exposure (Table 4). However, cadmium has been linked with carcinogenic effects due to inhalation, as indicated by an Inhalation Unit Risk (IUR) (Table 4). Studies with cadmium suggest that it is not carcinogenic orally; therefore no cancer risk estimates appear in the risk characterization for cadmium except for the inhalation pathway. EPA suggests that air concentrations be estimated and compared directly to the IUR; if cadmium air concentrations exceed 6 $\mu g/m^3$, then the IUR no longer applies. A cadmium air concentration due to particulates can be estimated with an emission factor (VF_p) derived with the following formula and conservative default parameters (ASTM, 1994):

$$VF_p[\frac{kg-soil}{m^3-air}] = \frac{P_e W}{U_{air}\delta_{air}} \times 10^3 \frac{cm^3-kg}{m^3-g} \qquad (7)$$

where:

P_e	=	Particulate emission rate (g/cm^2-s)	6.9×10^{-14}
W	=	Width of source area (cm)	1500
U_{air}	=	Wind speed (cm/s)	225
δ_{air}	=	Mixing zone height (cm)	200

Multiplying the VF_p of 2.3×10^{-12} by the cadmium soil concentration provides an estimate of cadmium air concentration as follows:

$$C_{air} = VF_p\,(\frac{kg}{m^3}) \times C_{soil}\,(\frac{mg}{kg}) \qquad (8)$$

The estimated cadmium air concentration is 1.84×10^{-13} mg/m^3 or 1.84×10^{-10} μg/m^3. As this is much lower than 6 μg/m^3 , the IUR can be applied.

Alternatively, a slope factor (SF) can be back-calculated from the IUR by dividing the IUR by the following parameters (EPA, 1989):

$$SF(mg/kg-d)^{-1} = IUR \div \frac{1}{70\ kg} \div 20\frac{m^3}{d} \div 10^{-3} \qquad (9)$$

The cadmium SF obtained by using Equation 9 is 6.3 (mg/kg-d)$^{-1}$. Both of these approaches to defining cadmium toxicity yield similar results in the Risk Characterization.

The leachate can potentially migrate to ground water (Figure 1). EPA (1994b) estimated soil concentrations below which no risk to receptors utilizing ground water is expected to occur. These soil concentrations are termed the Soil Screening Levels (SSLs). The SSLs are presented in Table 4. The CDPHE drinking water criteria are also presented in this table for comparison to the leachate concentrations of organics and inorganics.

2.3 Risk Characterization

The risk characterization compares the quantitative estimates of exposure to the toxicity criteria to determine risks based on both noncarcinogenic and carcinogenic health endpoints. Noncancer risk is addressed with the Hazard Quotient (HQ) which is obtained as follows:

$$HQ = \frac{Intake\ (mg/kg-d)}{RfD\ (mg/kg-d)} \qquad (10)$$

Cancer risk is obtained by multiplying the SF by the Intake as follows:

$$Risk = Intake\ (mg/kg-d) \times SF\ (mg/kg-d)^{-1} \qquad (11)$$

The carcinogenic and noncarcinogenic human health risks are presented in Table 5. The target cancer risk level for residents is 10^{-6}, whereas target worker risks typically fall in the range of 10^{-4} to 10^{-6}. A risk of 10^{-6} indicates that 1 person in 1 million exposed persons may contract

cancer as the result of exposure. The summation of cancer risks or HQs produces a cumulative cancer risk or noncancer risk estimate termed the Hazard Index (HI).

Workers exposed directly to leachate during management operations have a maximum cancer risk to any individual analyte of 2.46×10^{-4}, which is above the target risk range for workers. This maximum cancer risk was observed for pentachlorophenol, which was not detected in the leachate. The maximum noncancer risk (HQ) was 0.503 for heptachlor epoxide, which also was not detected in leachate. The HIs for workers contacting leachate for cancer and noncancer risks were 5.66×10^{-4} and 1.36, respectively. The risks were based on conservative exposure assumptions (CDPHE, 1994), and the assumption that contact with undiluted leachate would occur. Dermal contact is the driving risk pathway for the worker exposure scenario. It is assumed that appropriate industrial hygiene practices during leachate management operations will mitigate all potential worker risks.

All worker risks for contact with soils to which leachate is applied are below target risk levels for cancer risks (10^{-4} to 10^{-6}) or noncancer risks (1). All residential cancer risks for adults or children for contact with soils fall well below the target risk level (10^{-6}) for residential risk (Table 5). All noncancer risks for adult residents or children fall well below the target HQ of 1 (Table 5). The residential risks presume soil contact directly at the source at some point in the future after leachate management ceases.

The estimated cadmium air concentration is 1.84×10^{-13} mg/m^3 or 1.84×10^{-10} μg/m^3; multiplying by the IUR gives a cancer risk due to inhalation of 3.31×10^{-13}. Using equation 9 to back-calculate a slope factor for cadmium (Table 4) so that the CDPHE (1994) equation for inhalation of particulates can be used (Equation 3) provides a similarly low risk (Table 5).

The SSLs are soil concentrations below which adverse effects on groundwater due to leaching are not expected. None of the estimated soil concentrations that resulted from application of leachate to a 10 acre parcel exceeded soil screening levels (SSLs) based on a dilution attenuation factor (DAF) of 10 (EPA, 1994). A DAF of 10 is recommended since the application area is less than 30 acres; EPA (1994b) states that larger DAFs are appropriate when the source size is small. Thus, there is no potential risk to receptors utilizing ground water. This is consistent with new guidance proposed by CDPHE (1997), which contains soil screening levels protective of groundwater and acceptable concentrations in leachate for a limited number of constituents.

Many of the inorganic analytes exceed CDPHE drinking water standards (Compass, 1996). Barium and chromium are the only two inorganics that do not exceed CDPHE drinking water standards (Table 4). Many of the organics may also exceed drinking water standards; however, evaluation of the organics is based strictly on the detection limit as no organics were detected in leachate (Table 4). 1,4 Dichlorobenzene, 2,4,5 TP, benzene, and chlorobenzene are the only organics that do not have detection limits that exceed the CDPHE standards. However, as the leachate is not being proposed as a drinking water source, the CDPHE drinking water standards are not considered relevant.

CDPHE has proposed reference leachate concentrations for four of the compounds present in the reconstructed cell sump leachate. The maximum concentrations of arsenic, cadmium, lead, and inorganic mercury in leachate are below proposed leachate reference concentrations (CDPHE, 1997). The predicted concentrations in soil are all below proposed screening values for residential, commercial, or industrial land use (CDPHE, 1997).

2.4 Uncertainty Analysis

Many conservative assumptions, such as use of the maximum permeability constant for inorganics and the use of the minimum soil mass per acre, were made in preparing the human health risk assessment. Therefore, it is not anticipated that human health risks would be underestimated. Conservatively summing cancer risks due to all analytes is shown in the following table. Even using a value equal to the actual detection limit (instead of ½ that limit) does not increase the risks due to soil contact significantly, as can be seen by multiplying the cumulative cancer risk values by 2 for each exposure scenario as follows:

Exposure Scenario	Cumulative Cancer Risk	Cumulative Cancer Risk x 2
Worker - Leachate Contact	5.66×10^{-4}	1.13×10^{-3}
Worker - Soil Contact	1.48×10^{-8}	2.97×10^{-8}
Child - Soil Contact	2.14×10^{-7}	4.28×10^{-7}
Adult - Soil Contact	2.68×10^{-7}	5.36×10^{-7}

Conservatively summing noncancer risks due to all analytes is shown by the HI in the following table. This is conservative because not all toxic effects are additive; some may be antagonistic, while others may be synergistic. Even using a value equal to the actual detection limit (instead of ½ that limit) does not increase the risks due to soil contact significantly, as can be seen by multiplying the HI values for noncancer risk by 2 for each exposure scenario as follows:

Exposure Scenario	Hazard Index	Hazard Index x 2
Worker - Leachate Contact	1.36	2.73
Worker - Soil Contact	0.001	0.002
Child - Soil Contact	0.004	0.008
Adult - Soil Contact	0.005	0.01

2.5 Conclusion

The management option of land application does not present a substantial risk to workers or potential future residents for exposure to soils to which the leachate was applied. However, direct dermal contact with the leachate may present a potential risk to workers, and appropriate precautions should be taken to avoid dermal contact or ingestion. A requirement to wear water repellant boots, coveralls, and gloves, as well as safety glasses, when handling the leachate should be sufficient. Verification of these recommendations should be made with WMC's Certified Industrial Hygienist (CIH), and incorporated into a Health and Safety Plan (HSP).

Groundwater will not be adversely affected according to the assumptions made in the risk assessment. This conclusion is based on comparison of predicted soil concentrations due to leachate application to Federal and State soil screening levels. It is also based on comparison of leachate concentrations to reference leachate concentrations proposed by the CDPHE.

3.0 Ecological Risk Assessment

3.1 Problem Formulation

There are many ecological receptors (i.e., bird and mammal species) in a given environment; thus, a subset must be selected upon which to develop quantitative risk estimates. In conducting ecological risk assessment, receptors are selected that are expected to be highly exposed based on their life history traits. By selecting receptors that are more highly exposed, it is assumed that risks to less highly exposed receptors will be addressed. Receptors that are highly exposed because of their life history traits (i.e., feeding behavior, dietary preferences, etc.) are typically ground-feeding birds or burrowing mammals. Birds that feed on the ground are expected to ingest more soil per unit body weight than avian species that feed in trees or shrubs. Small burrowing mammals are also expected to contact soils at a higher rate than a large mammal that browses on shrubs.

Three receptors were identified as potential ecological receptors. Two are terrestrial (i.e., live on the ground). These receptors are the American robin, which is a ground feeding bird; and the deer mouse, which is a burrowing mammal that frequents disturbed habitat. Both of these receptors are expected to be more highly exposed than other receptors due to their life history traits. Benthic invertebrates as a group were selected to represent aquatic risks. Benthic invertebrates include stream insects that live in the sediments, and are often more sensitive to toxicants than are fish. Benthic invertebrates are important because they represent toxicity to other types of aquatic life, such as trout, and also form the prey base for the aquatic ecosystem.

3.2 Exposure Analysis

The EPCs to which ecological receptors are considered to be exposed are the same as those estimated for human exposure. Ecological receptors were presumed to avoid being sprayed with leachate during the time it was applied to soil; however, birds and mammals may contact the soils to which leachate was applied (Figure 2). In addition, aquatic life may be exposed to leachate if any run-off enters a stream system (Figure 2). Birds and mammals could utilize ponded leachate on the soil surface for a drinking water source.

Exposure was addressed for the following pathways (Figure 2):

- ingestion of surface soil to which leachate was applied (robin and deer mouse),
- dermal contact with surface soil to which leachate was applied (robin and deer mouse),
- ingestion of leachate ponded or puddled on surface soils (robin and deer mouse), and
- direct contact with leachate run-off which drained to a stream (benthic invertebrates).

The equations used to estimate exposure intakes for ecological receptors are similar to those used to estimate exposure by humans. However, it is assumed that ecological receptors would be exposed daily throughout their lifetimes. Therefore, the parameters to adjust for duration (EF, ED, AT) are absent from the equations for ecological receptors. Specifically, the equation for chemical intake (mg/kg bw/d) due to soil ingestion is:

$$Intake = Csoil \times DIR \times SF / 100 \quad (12)$$

The contact rate for ingestion of soil is normalized to body weight (Table 6), therefore the equation appears somewhat different than those for human health exposure.

The equation for dermal uptake of contaminants from soil (mg/kg bw/d) by birds and mammals is:

$$Intake = \frac{Csoil \times SA \times AB \times AF \times CF}{BW} \quad (13)$$

The values for the parameters CF, AF and AB are the same as those used in the human health equations (Table 2). The units of the parameter surface area (SA) differ in that ecological receptors are presumed to be exposed per day (i.e., instead of event), since complete washing and removal of soil on an event basis is unlikely.

The equation for chemical intake (mg/kg bw/d) due to ingestion of leachate by birds and mammals is:

$$Intake = C_{leachate} \times WIR \quad (14)$$

The contact rate for ingestion of leachate is normalized to body weight, and therefore the equation for ingestion of leachate appears slightly different than that in the human health risk assessment.

The parameters used to obtain the exposure intakes for ecological receptors, their abbreviations, and the units for each parameter, are presented in Table 6. The most conservative estimate of each parameter was used to estimate exposure from available data (EPA, 1993). The 95th

percentile is the most conservative estimate, except for the parameter body weight (BW) which appears in the denominator of the exposure equations. For body weight, the minimum value was used as the most conservative estimator. Additional conservatism is incorporated by not applying an Area Use Factor (AUF) to adjust for the fact that the animals home range likely exceeds the source area, thereby diluting exposure. Exposure intakes are not estimated for benthic invertebrates. Instead, the leachate concentrations are compared directly to the Ambient Water Quality Criteria (AWQC) in order to obtain a Hazard Quotient. Table 7 presents the exposure intakes for each exposure pathway for the robin and the mouse.

3.3 Toxicity and Ecological Effects Analysis

Toxicity to ecological receptors is addressed by developing a list of toxicity benchmark values (TBVs) from the literature. The literature was reviewed to obtain No Observed Adverse Effect Levels (NOAELs), which are typically dietary concentrations of each contaminant that produce no adverse effects when administered chronically. The toxicity benchmarks are presented in Table 8. When a TBV is lacking, quantitative risk assessment cannot be performed for that receptor. Because birds and mammals are so different physiologically, different toxicity criteria were developed to estimate risks to these different taxa. Extrapolating toxicity values across phyla is not recommended (Fordham and Reagan, 1991).

Uncertainty factors (UFs) have been applied to adjust the toxicity values to reflect uncertainty in the study used to obtain an estimate of chronic (long-term) No Observed Adverse Effect Levels (NOAELs). The UF scheme is presented in Table 9, and is consistent with current EPA Region VIII practice. Appendix B presents detailed information used in developing the Toxicity Benchmark Values (TBVs).

3.4 Risk Characterization

Risks to ecological receptors are addressed by calculating an HQ, similar to that for assessing human health noncancer risk (Equation 10). The leachate concentration was divided by the AWQC to obtain HQs for aquatic life. The exposure intakes (Table 7) were divided by the TBVs (Table 8) to obtain HQs for American robins and deer mice.

Risks to benthic invertebrates exceeded 1 for several organics and inorganics, assuming that leachate applied directly to soil ran off of the surface into a stream system (Table 10). Thus, applying leachate for dust suppression next to or in close proximity to a stream system should be avoided. Some of the HQs for benthic invertebrates were very high, and exceeded 10 and 100. Because the AWQC are protective not only of benthic invertebrates, but other forms of aquatic

life as well, risk estimates for benthic invertebrates are applicable to addressing potential risks to fish as well.

Drinking leachate produced an HQ in excess of 1 for the deer mouse, although this HQ was low (Table 10). Given the conservatism built into the toxicity benchmark values (i.e., uncertainty factors, use of a chronic NOAEL as the benchmark), it is unlikely that any adverse effects to populations of deer mice would occur. Management of the leachate by application to soils did not produce risks to ecological receptors likely to contact soils (Table 10).

3.5 Uncertainty Analysis

Although risks to ecological receptors are inherently more uncertain than those for human health risks since numerous, and phylogenetically unrelated species are addressed, use of numerous conservative assumptions makes underestimation of risk unlikely. A major conservative assumption used in the risk assessment was that no adjustment for the animals' home range was used. This means that 100% of exposure throughout the lifetime of the animal occurs directly at the source. This is highly unlikely, since prey and forage availability directly at the source (i.e., a road or area requiring dust suppression) would not support a population of most species of animals. It is more likely that individual animals would move in and out of the 10 acre parcel, and thus not experience chronic exposure.

Ecological risk assessment focuses on risks to populations, not individuals, unless they are threatened or endangered. This risk assessment conservatively evaluated risks to individuals since an AUF was not applied, thereby assessing risks to potentially occurring threatened and endangered species as well.

Use of the maximum leachate concentration for inorganics, or ½ the maximum detection limit for organics, is highly conservative since it ignores the statistical range of concentrations exhibited by the extensive analytical data collected for the leachate. The use of chronic NOAELs as toxicity benchmark values is also conservative especially since the proposed area of leachate application is small, and unlikely to be used on a chronic basis as the sole feeding territory or home range for any population of birds or mammals.

4.0 Summary and Conclusions

Risks to potential future residential receptors are well below target risk levels. Risks to workers and ecological health are highest for contact directly with the leachate. However, appropriate worker protection would mitigate human health risks due to contact with leachate. Risks to aquatic life would be high if the leachate were allowed to enter a stream system since concentrations of several of the analytes in the leachate exceed the EPA Ambient Water Quality Criteria for the Protection of Aquatic Life and their Uses (AWQC). Therefore, application of leachate to soil directly next to a stream ecosystem should be avoided.

The potential risk to human health or to terrestrial receptors is minimal to nonexistent when the leachate is applied to soils for dust suppression. Therefore, the soil application option should be considered an appropriate management option for the reconstructed cell sump leachate.

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TABLES

Table 1. Summary Statistics for All Analytes in the Reconstructed Cell Sump Leachate (mg/L).

	n	Frequency of Detection (%)	Minimum	Maximum	Arithmetic Mean	Standard Deviation	UCL95	Geometric Mean
Inorganics:								
Arsenic	27	7.4	0.025	0.110	0.031	0.021	0.039	0.028
Barium	27	29.6	0.10	0.700	0.264	0.116	0.308	0.244
Cadmium	27	100.0	0.010	0.080	0.035	0.016	0.041	0.032
Chromium	27	7.4	0.005	0.030	0.006	0.005	0.008	0.005
Cyanide	27	74.1	0.01	0.280	0.047	0.055	0.068	0.031
Lead	27	0.0	0.005	0.100	0.027	0.015	0.033	0.025
Mercury	27	48.1	0.001	0.014	0.007	0.004	0.008	0.005
Nickel	26	92.3	0.02	0.510	0.205	0.098	0.243	0.179
Selenium	27	40.7	0.005	0.300	0.102	0.078	0.131	0.076
Silver	27	29.6	0.005	0.160	0.015	0.031	0.027	0.008
Thallium	26	30.8	0.005	0.300	0.083	0.068	0.109	0.064
Organics:								
Benzene	27	0	0.005	0.005				
1,1 Dichloroethene	27	0	0.025	0.025				
1,2 Dichloroethane	27	0	0.025	0.025				
1.4 Dichlorobenzene	27	0	0.005	0.050				
2,4 D	27	0	0.000003	0.250				
2,4 Dintirotoluene	27	0	0.005	0.050				
2,4,5 TP	27	0	0.000001	0.050				
2,4,5 Trichlorophenol	27	0	0.005	0.050				
2,4,6 Trichlorophenol	27	0	0.005	0.050				
Carbon tetrachloride	27	0	0.025	0.025				
Chlordane	27	0	0.001	0.007				
Chlorobenzene	27	0	0.025	0.025				
Chloroform	27	0	0.025	0.025				
Endrin	27	0	0.0003	0.003				
gamma BHC	27	0	0.0002	0.002				
Heptachlor	27	0	0.0002	0.002				
Heptachlor epoxide	27	0	0.0002	0.042				
Hexachlorobenzene	27	0	0.005	0.050				
Hexachlorobutadiene	27	0	0.005	0.050				
Hexachloroethane	27	0	0.005	0.050				
m&p Cresol	27	0	0.005	0.050				
Methl ethyl ketone	27	0	0.500	0.500				
Methoxychlor	27	0	0.009	0.090				
Nitrobenzene	27	0	0.005	0.050				
o-Cresol	27	0	0.005	0.050				
Pentachlorophenol	27	0	0.025	0.250				
Pyridine	19	0	0.05	0.050				
Tetrachloroethene	27	0	0.025	0.025				
Toxaphene	27	0	0.012	0.120				
Trichloroethene	27	0	0.025	0.025				
Vinyl chloride	27	0	0.05	0.050				

Summary statistics were not calculated for the organics because all of the data were below detection. A value of 1/2 the maximum detection limit for each analyte was used to represent the Exposure Point Concentration (EPC) for that analyte.

Table 2. Parameters Used in the Exposure Intake Equations for Each Receptor.

Parameter	Abbreviation	Units	Worker	Child	Adult
Body Weight	BW	kg	70	15	70
AT_cancer	AT	days	25550	25550	25550
AT_noncancer	AT	days	3650	10950	10950
Ingestion rate, leachate	CR	L/hr	0.001	NA	NA
Ingestion rate, soil	IR	mg/d	480	200	100
Exposure time	ET	hr/d hr/event	8	24	24
Exposure frequency	EF	day/yr event/yr	60	350	350
Exposure duration	ED	yr	10	6	24
Surface area, body	SA	cm2	4700	4600	7100
Conversion factor, weight	CF	kg/mg	1.00E-06	1.00E-06	1.00E-06
Conversion factor, volume	CFw	L/cm3	0.001	0.001	0.001
Permeability constant (inorganics)	PC	cm/h	*1.00E-03*	NA	NA
Cadmium		*cm/h*	*1.00E-03*	NA	NA
Chromium		*cm/h*	*1.00E-03*	NA	NA
Mercury		*cm/h*	*1.00E-03*	NA	NA
Nickel		*cm/h*	*1.00E-04*	NA	NA
Silver		*cm/h*	*6.00E-04*	NA	NA
Permeability constant (organics)	PC	cm/h	*1.00E-02*	NA	NA
1,1 Dichloroethene		*cm/h*	*1.60E-02*	NA	NA
1,2 Dichloroethane		*cm/h*	*5.30E-03*	NA	NA
1.4 Dichlorobenzene		*cm/h*	*6.20E-02*	NA	NA
2,4 D	*	*cm/h*	*1.00E-02*	NA	NA
2,4 Dintirotoluene		*cm/h*	*3.80E-03*	NA	NA
2,4,5 TP	*	*cm/h*	*1.00E-02*	NA	NA
2,4,5 Trichlorophenol	*	*cm/h*	*1.01E+00*	NA	NA
2,4,6 Trichlorophenol		*cm/h*	*5.00E-02*	NA	NA
Benzene		*cm/h*	*2.10E-02*	NA	NA
Butadiene		*cm/h*	*2.30E-02*	NA	NA
Carbon tetrachloride		*cm/h*	*2.20E-02*	NA	NA
Chloroform		*cm/h*	*8.90E-03*	NA	NA
Cresols		*cm/h*	*1.00E-02*	NA	NA
Chlordane		*cm/h*	*5.20E-02*	NA	NA
Chlorobenzene		*cm/h*	*4.10E-02*	NA	NA
Endrin		*cm/h*	*1.60E-02*	NA	NA
gamma BHC		*cm/h*	*1.40E-02*	NA	NA
Heptachlor		*cm/h*	*1.10E-02*	NA	NA
Heptachlor epoxide		*cm/h*	*1.10E-02*	NA	NA
Hexachlorobenzene		*cm/h*	*2.10E-01*	NA	NA
Hexachlorobutadiene		*cm/h*	*1.20E-01*	NA	NA
Hexachloroethane		*cm/h*	*4.20E-02*	NA	NA
m&p Cresol		*cm/h*	*1.00E-02*	NA	NA
Methl ethyl ketone		*cm/h*	*1.10E-03*	NA	NA
Methoxychlor	*	*cm/h*	*1.00E-02*	NA	NA
Nitrobenzene	*	*cm/h*	*1.00E-02*	NA	NA
o-Cresol		*cm/h*	*1.00E-02*	NA	NA
Pentachlorophenol		*cm/h*	*6.50E-01*	NA	NA
Pyridine	*	*cm/h*	*1.00E-02*	NA	NA
Tetrachloroethene		*cm/h*	*4.80E-02*	NA	NA
Toxaphene		*cm/h*	*1.50E-02*	NA	NA
Trichloroethene		*cm/h*	*1.60E-02*	NA	NA
Vinyl chloride		*cm/h*	*7.30E-03*	NA	NA
Absorption Factor	AB	unitless	*0.5*	0.5	0.5
Adherence Factor	AF	mg/cm2/event	1.0	1.0	1.0
Particulate Emission Factor	PEF	m3/mg	4630	4630	4630
Inhalation rate	INH	m3/hr	0.83	0.73	0.83

Notes:

The ingestion rate for leachate was assumed in lieu of any regulatory guidance

The maximum PC for inorganics was used to represent the PC for all inorganics evaluated

*A PC of 1E-2 was assumed for organics marked with a **

Source:

CDPHE, 1994

EPA, 1989

EPA, 1992b

Table 3. Exposure Point Concentrations and Exposure Intakes for Each Human Health Scenario (1 of 4).

Scenario: Cancer Risk - Contact Directly with Leachate

		Worker (mg/kg/d)				Resident - Child (mg/kg/d)				Resident - Adult (mg/kg/d)			
Analyte	**EPC (mg/L)**	**Leachate Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**
Inorganics:													
Arsenic	0.110	2.95E-07	1.39E-06	NA	1.683E-06								
Barium	0.700	1.88E-06	8.83E-06	NA	1.071E-05								
Cadmium	0.080	2.15E-07	1.01E-06	NA	1.224E-06								
Chromium	0.030	8.05E-08	3.78E-07	NA	4.589E-07								
Cyanide	0.280	7.51E-07	3.53E-06	NA	4.283E-06								
Lead	0.100	2.68E-07	1.26E-06	NA	1.530E-06								
Mercury	0.014	3.76E-08	1.77E-07	NA	2.142E-07								
Nickel	0.510	1.37E-06	6.43E-06	NA	7.802E-06								
Selenium	0.300	8.05E-07	3.78E-06	NA	4.589E-06								
Silver	0.160	4.29E-07	2.02E-06	NA	2.448E-06								
Thallium	0.300	8.05E-07	3.78E-06	NA	4.589E-06								
Organics:													
Benzene	0.005	1.34E-08	1.32E-06	NA	1.338E-06								
1,1 Dichloroethene	0.025	6.71E-08	5.05E-06	NA	5.113E-06								
1,2 Dichloroethane	0.025	6.71E-08	1.67E-06	NA	1.738E-06								
1.4 Dichlorobenzene	0.050	1.34E-07	3.91E-05	NA	3.924E-05								
2,4 D	0.250	6.71E-07	3.15E-05	NA	3.221E-05								
2,4 Dintirotoluene	0.050	1.34E-07	2.40E-06	NA	2.531E-06								
2,4,5 TP	0.050	1.34E-07	6.31E-06	NA	6.441E-06								
2,4,5 Trichlorophenol	0.050	1.34E-07	6.37E-04	NA	6.371E-04								
2,4,6 Trichlorophenol	0.050	1.34E-07	3.15E-05	NA	3.167E-05								
Carbon tetrachloride	0.025	6.71E-08	6.94E-06	NA	7.005E-06								
Chlordane	0.007	1.88E-08	4.59E-06	NA	4.610E-06								
Chlorobenzene	0.025	6.71E-08	1.29E-05	NA	1.300E-05								
Chloroform	0.025	6.71E-08	2.81E-06	NA	2.874E-06								
Endrin	0.003	8.05E-09	6.05E-07	NA	6.135E-07								
gamma BHC	0.002	5.37E-09	3.53E-07	NA	3.586E-07								
Heptachlor	0.002	4.03E-09	2.08E-07	NA	2.122E-07								
Heptachlor epoxide	0.042	1.11E-07	5.76E-06	NA	5.870E-06								
Hexachlorobenzene	0.050	1.34E-07	1.32E-04	NA	1.326E-04								
Hexachlorobutadiene	0.050	1.34E-07	7.57E-05	NA	7.582E-05								
Hexachloroethane	0.050	1.34E-07	2.65E-05	NA	2.662E-05								
m&p Cresol	0.050	1.34E-07	6.31E-06	NA	6.441E-06								
Methl ethyl ketone	0.500	1.34E-06	6.94E-06	NA	8.280E-06								
Methoxychlor	0.090	2.42E-07	1.14E-05	NA	1.159E-05								
Nitrobenzene	0.050	1.34E-07	6.31E-06	NA	6.441E-06								
o-Cresol	0.050	1.34E-07	6.31E-06	NA	6.441E-06								
Pentachlorophenol	0.250	6.71E-07	2.05E-03	NA	2.050E-03								
Pyridine	0.050	1.34E-07	6.31E-06	NA	6.441E-06								
Tetrachloroethene	0.025	6.71E-08	1.51E-05	NA	1.520E-05								
Toxaphene	0.120	3.22E-07	2.27E-05	NA	2.303E-05								
Trichloroethene	0.025	6.71E-08	5.05E-06	NA	5.113E-06								
Vinyl chloride	0.050	1.34E-07	4.60E-06	NA	4.738E-06								

Residential pathways not applicable for contact with leachate as this is not a current use.

Table 3. Exposure Point Concentrations and Exposure Intakes for Each Human Health Scenario (2 of 4).

Scenario: Cancer Risk - Contact with Soils to Which Leachate Applied

		Worker (mg/kg/d)				Resident - Child (mg/kg/d)				Resident - Adult (mg/kg/d)			
Analyte	**EPC (mg/kg)**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**
Inorganics:													
Arsenic	0.002	3.01E-10	1.47E-09	8.979E-16	1.772E-09	2.045E-09	2.352E-08	3.870E-14	2.557E-08	8.765E-10	3.112E-08	3.771E-14	3.199E-08
Barium	0.012	1.91E-09	9.36E-09	5.714E-15	1.128E-08	1.302E-08	1.497E-07	2.463E-13	1.627E-07	5.578E-09	1.980E-07	2.400E-13	2.036E-07
Cadmium	0.001	2.19E-10	1.07E-09	6.530E-16	1.289E-09	1.487E-09	1.711E-08	2.814E-14	1.859E-08	6.375E-10	2.263E-08	2.743E-14	2.327E-08
Chromium	0.001	8.20E-11	4.01E-10	2.449E-16	4.832E-10	5.578E-10	6.415E-09	1.055E-14	6.973E-09	2.391E-10	8.487E-09	1.029E-14	8.726E-09
Cyanide	0.005	7.65E-10	3.75E-09	2.286E-15	4.510E-09	5.206E-09	5.987E-08	9.850E-14	6.508E-08	2.231E-09	7.921E-08	9.599E-14	8.144E-08
Lead	0.002	2.73E-10	1.34E-09	8.163E-16	1.611E-09	1.859E-09	2.138E-08	3.518E-14	2.324E-08	7.969E-10	2.829E-08	3.428E-14	2.909E-08
Mercury	0.0002	3.82E-11	1.87E-10	1.143E-16	2.255E-10	2.603E-10	2.994E-09	4.925E-15	3.254E-09	1.116E-10	3.960E-09	4.800E-15	4.072E-09
Nickel	0.009	1.39E-09	6.82E-09	4.163E-15	8.215E-09	9.483E-09	1.090E-07	1.794E-13	1.185E-07	4.064E-09	1.443E-07	1.748E-13	1.483E-07
Selenium	0.005	8.20E-10	4.01E-09	2.449E-15	4.832E-09	5.578E-09	6.415E-08	1.055E-13	6.973E-08	2.391E-09	8.487E-08	1.029E-13	8.726E-08
Silver	0.003	4.37E-10	2.14E-09	1.306E-15	2.577E-09	2.975E-09	3.421E-08	5.629E-14	3.719E-08	1.275E-09	4.526E-08	5.485E-14	4.654E-08
Thallium	0.005	8.20E-10	4.01E-09	2.449E-15	4.832E-09	5.578E-09	6.415E-08	1.055E-13	6.973E-08	2.391E-09	8.487E-08	1.029E-13	8.726E-08
Organics:													
Benzene	0.00008	1.37E-11	6.69E-11	4.081E-17	8.054E-11	9.297E-11	1.069E-09	1.759E-15	1.162E-09	3.984E-11	1.414E-09	1.714E-15	1.454E-09
1,1 Dichloroethene	0.00042	6.83E-11	3.34E-10	2.041E-16	4.027E-10	4.648E-10	5.346E-09	8.795E-15	5.810E-09	1.992E-10	7.072E-09	8.571E-15	7.271E-09
1,2 Dichloroethane	0.00042	6.83E-11	3.34E-10	2.041E-16	4.027E-10	4.648E-10	5.346E-09	8.795E-15	5.810E-09	1.992E-10	7.072E-09	8.571E-15	7.271E-09
1,4 Dichlorobenzene	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08
2,4 D	0.00424	6.83E-10	3.34E-09	2.041E-15	4.027E-09	4.648E-09	5.346E-08	8.795E-14	5.810E-08	1.992E-09	7.072E-08	8.571E-14	7.271E-08
2,4 Dintirotoluene	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08
2,4,5 TP	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08
2,4,5 Trichlorophenol	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08
2,4,6 Trichlorophenol	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08
Carbon tetrachloride	0.00042	6.83E-11	3.34E-10	2.041E-16	4.027E-10	4.648E-10	5.346E-09	8.795E-15	5.810E-09	1.992E-10	7.072E-09	8.571E-15	7.271E-09
Chlordane	0.00012	1.91E-11	9.36E-11	5.714E-17	1.128E-10	1.302E-10	1.497E-09	2.463E-15	1.627E-09	5.578E-11	1.980E-09	2.400E-15	2.036E-09
Chlorobenzene	0.00042	6.83E-11	3.34E-10	2.041E-16	4.027E-10	4.648E-10	5.346E-09	8.795E-15	5.810E-09	1.992E-10	7.072E-09	8.571E-15	7.271E-09
Chloroform	0.00042	6.83E-11	3.34E-10	2.041E-16	4.027E-10	4.648E-10	5.346E-09	8.795E-15	5.810E-09	1.992E-10	7.072E-09	8.571E-15	7.271E-09
Endrin	0.00005	8.20E-12	4.01E-11	2.449E-17	4.832E-11	5.578E-11	6.415E-10	1.055E-15	6.973E-10	2.391E-11	8.487E-10	1.029E-15	8.726E-10
gamma BHC	0.00003	5.46E-12	2.68E-11	1.633E-17	3.222E-11	3.719E-11	4.276E-10	7.036E-16	4.648E-10	1.594E-11	5.658E-10	6.857E-16	5.817E-10
Heptachlor	0.00003	4.10E-12	2.01E-11	1.224E-17	2.416E-11	2.789E-11	3.207E-10	5.277E-16	3.486E-10	1.195E-11	4.243E-10	5.143E-16	4.363E-10
Heptachlor epoxide	0.00070	1.13E-10	5.55E-10	3.388E-16	6.685E-10	7.716E-10	8.874E-09	1.460E-14	9.645E-09	3.307E-10	1.174E-08	1.423E-14	1.207E-08
Hexachlorobenzene	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08
Hexachlorobutadiene	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08
Hexachloroethane	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08
m&p Cresol	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08
Methl ethyl ketone	0.00848	1.37E-09	6.69E-09	4.081E-15	8.054E-09	9.297E-09	1.069E-07	1.759E-13	1.162E-07	3.984E-09	1.414E-07	1.714E-13	1.454E-07
Methoxychlor	0.00153	2.46E-10	1.20E-09	7.347E-16	1.450E-09	1.673E-09	1.924E-08	3.166E-14	2.092E-08	7.172E-10	2.546E-08	3.086E-14	2.618E-08
Nitrobenzene	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08
o-Cresol	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08
Pentachlorophenol	0.00424	6.83E-10	3.34E-09	2.041E-15	4.027E-09	4.648E-09	5.346E-08	8.795E-14	5.810E-08	1.992E-09	7.072E-08	8.571E-14	7.271E-08
Pyridine	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08
Tetrachloroethene	0.00042	6.83E-11	3.34E-10	2.041E-16	4.027E-10	4.648E-10	5.346E-09	8.795E-15	5.810E-09	1.992E-10	7.072E-09	8.571E-15	7.271E-09
Toxaphene	0.00204	3.28E-10	1.61E-09	9.795E-16	1.933E-09	2.231E-09	2.566E-08	4.221E-14	2.789E-08	9.562E-10	3.395E-08	4.114E-14	3.490E-08
Trichloroethene	0.00042	6.83E-11	3.34E-10	2.041E-16	4.027E-10	4.648E-10	5.346E-09	8.795E-15	5.810E-09	1.992E-10	7.072E-09	8.571E-15	7.271E-09
Vinyl chloride	0.00085	1.37E-10	6.69E-10	4.081E-16	8.054E-10	9.297E-10	1.069E-08	1.759E-14	1.162E-08	3.984E-10	1.414E-08	1.714E-14	1.454E-08

Table 3. Exposure Point Concentrations and Exposure Intakes for Each Human Health Scenario (3 of 4).

Scenario: Noncancer Risk - Contact Directly with Leachate

		Worker (mg/kg/d)				Resident - Child (mg/kg/d)				Resident - Adult (mg/kg/d)			
Analyte	**EPC (mg/L)**	**Leachate Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**
Inorganics:													
Arsenic	0.110	2.07E-06	9.71E-06	NA	1.178E-05								
Barium	0.700	1.32E-05	6.18E-05	NA	7.496E-05								
Cadmium	0.080	1.50E-06	7.06E-06	NA	8.567E-06								
Chromium	0.030	5.64E-07	2.65E-06	NA	3.213E-06								
Cyanide	0.280	5.26E-06	2.47E-05	NA	2.998E-05								
Lead	0.100	1.88E-06	8.83E-06	NA	1.071E-05								
Mercury	0.014	2.63E-07	1.24E-06	NA	1.499E-06								
Nickel	0.510	9.58E-06	4.50E-05	NA	5.461E-05								
Selenium	0.300	5.64E-06	2.65E-05	NA	3.213E-05								
Silver	0.160	3.01E-06	1.41E-05	NA	1.713E-05								
Thallium	0.300	5.64E-06	2.65E-05	NA	3.213E-05								
Organics:													
Benzene	0.005	9.39E-08	1.32E-06	NA	1.418E-06								
1,1 Dichloroethene	0.025	4.70E-07	5.05E-06	NA	5.515E-06								
1,2 Dichloroethane	0.025	4.70E-07	1.67E-06	NA	2.141E-06								
1,4 Dichlorobenzene	0.050	9.39E-07	3.91E-05	NA	4.004E-05								
2,4 D	0.250	4.70E-06	3.15E-05	NA	3.623E-05								
2,4 Dintirotoluene	0.050	9.39E-07	2.40E-06	NA	3.336E-06								
2,4,5 TP	0.050	9.39E-07	6.31E-06	NA	7.246E-06								
2,4,5 Trichlorophenol	0.050	9.39E-07	6.37E-04	NA	6.379E-04								
2,4,6 Trichlorophenol	0.050	9.39E-07	3.15E-05	NA	3.247E-05								
Carbon tetrachloride	0.025	4.70E-07	6.94E-06	NA	7.407E-06								
Chlordane	0.007	1.32E-07	4.59E-06	NA	4.723E-06								
Chlorobenzene	0.025	4.70E-07	1.29E-05	NA	1.340E-05								
Chloroform	0.025	4.70E-07	2.81E-06	NA	3.276E-06								
Endrin	0.003	5.64E-08	6.05E-07	NA	6.618E-07								
gamma BHC	0.002	3.76E-08	3.53E-07	NA	3.908E-07								
Heptachlor	0.002	2.82E-08	2.08E-07	NA	2.363E-07								
Heptachlor epoxide	0.042	7.80E-07	5.76E-06	NA	6.538E-06								
Hexachlorobenzene	0.050	9.39E-07	1.32E-04	NA	1.334E-04								
Hexachlorobutadiene	0.050	9.39E-07	7.57E-05	NA	7.662E-05								
Hexachloroethane	0.050	9.39E-07	2.65E-05	NA	2.743E-05								
m&p Cresol	0.050	9.39E-07	6.31E-06	NA	7.246E-06								
Methl ethyl ketone	0.500	9.39E-06	6.94E-06	NA	1.633E-05								
Methoxychlor	0.090	1.69E-06	1.14E-05	NA	1.304E-05								
Nitrobenzene	0.050	9.39E-07	6.31E-06	NA	7.246E-06								
o-Cresol	0.050	9.39E-07	6.31E-06	NA	7.246E-06								
Pentachlorophenol	0.250	4.70E-06	2.05E-03	NA	2.054E-03								
Pyridine	0.050	9.39E-07	6.31E-06	NA	7.246E-06								
Tetrachloroethene	0.025	4.70E-07	1.51E-05	NA	1.561E-05								
Toxaphene	0.120	2.25E-06	2.27E-05	NA	2.496E-05								
Trichloroethene	0.025	4.70E-07	5.05E-06	NA	5.515E-06								
Vinyl chloride	0.050	9.39E-07	4.60E-06	NA	5.543E-06								

Residential pathways not applicable for contact with leachate as this is not a current use.

Table 3. Exposure Point Concentrations and Exposure Intakes for Each Human Health Scenario (4 of 4).

Scenario: Noncancer Risk - Contact with Soils to Which Leachate Applied

		Worker (mg/kg/d)				Resident - Child (mg/kg/d)				Resident - Adult (mg/kg/d)			
Analyte	**EPC (mg/kg)**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**
Inorganics:													
Arsenic	0.002	2.10E-09	1.03E-08	6.285E-15	1.240E-08	4.772E-09	5.488E-08	9.029E-14	5.965E-08	2.045E-09	7.261E-08	8.800E-14	7.465E-08
Barium	0.012	1.34E-08	6.55E-08	4.00E-14	7.89E-08	3.04E-08	3.49E-07	5.75E-13	3.80E-07	1.30E-08	4.62E-07	5.60E-13	4.75E-07
Cadmium	0.001	1.53E-09	7.49E-09	4.57E-15	9.02E-09	3.47E-09	3.99E-08	6.57E-14	4.34E-08	1.49E-09	5.28E-08	6.40E-14	5.43E-08
Chromium	0.001	5.74E-10	2.81E-09	1.71E-15	3.38E-09	1.30E-09	1.50E-08	2.46E-14	1.63E-08	5.58E-10	1.98E-08	2.40E-14	2.04E-08
Cyanide	0.005	5.35E-09	2.62E-08	1.60E-14	3.16E-08	1.21E-08	1.40E-07	2.30E-13	1.52E-07	5.21E-09	1.85E-07	2.24E-13	1.90E-07
Lead	0.002	1.91E-09	9.36E-09	5.71E-15	1.13E-08	4.34E-09	4.99E-08	8.21E-14	5.42E-08	1.86E-09	6.60E-08	8.00E-14	6.79E-08
Mercury	0.0002	2.68E-10	1.31E-09	8.00E-16	1.58E-09	6.07E-10	6.98E-09	1.15E-14	7.59E-09	2.60E-10	9.24E-09	1.12E-14	9.50E-09
Nickel	0.009	9.75E-09	4.78E-08	2.91E-14	5.75E-08	2.21E-08	2.54E-07	4.19E-13	2.77E-07	9.48E-09	3.37E-07	4.08E-13	3.46E-07
Selenium	0.005	5.74E-09	2.81E-08	1.71E-14	3.38E-08	1.30E-08	1.50E-07	2.46E-13	1.63E-07	5.58E-09	1.98E-07	2.40E-13	2.04E-07
Silver	0.003	3.06E-09	1.50E-08	9.14E-15	1.80E-08	6.94E-09	7.98E-08	1.31E-13	8.68E-08	2.97E-09	1.06E-07	1.28E-13	1.09E-07
Thallium	0.005	5.74E-09	2.81E-08	1.71E-14	3.38E-08	1.30E-08	1.50E-07	2.46E-13	1.63E-07	5.58E-09	1.98E-07	2.40E-13	2.04E-07
Organics:													
Benzene	0.00008	9.56E-11	4.68E-10	2.86E-16	5.64E-10	2.17E-10	2.49E-09	4.10E-15	2.71E-09	9.30E-11	3.30E-09	4.00E-15	3.39E-09
1,1 Dichloroethene	0.00042	4.78E-10	2.34E-09	1.43E-15	2.82E-09	1.08E-09	1.25E-08	2.05E-14	1.36E-08	4.65E-10	1.65E-08	2.00E-14	1.70E-08
1,2 Dichloroethane	0.00042	4.78E-10	2.34E-09	1.43E-15	2.82E-09	1.08E-09	1.25E-08	2.05E-14	1.36E-08	4.65E-10	1.65E-08	2.00E-14	1.70E-08
1,4 Dichlorobenzene	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08
2,4 D	0.00424	4.78E-09	2.34E-08	1.43E-14	2.82E-08	1.08E-08	1.25E-07	2.05E-13	1.36E-07	4.65E-09	1.65E-07	2.00E-13	1.70E-07
2,4 Dintirotoluene	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08
2,4,5 TP	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08
2,4,5 Trichlorophenol	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08
2,4,6 Trichlorophenol	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08
Carbon tetrachloride	0.00042	4.78E-10	2.34E-09	1.43E-15	2.82E-09	1.08E-09	1.25E-08	2.05E-14	1.36E-08	4.65E-10	1.65E-08	2.00E-14	1.70E-08
Chlordane	0.00012	1.34E-10	6.55E-10	4.00E-16	7.89E-10	3.04E-10	3.49E-09	5.75E-15	3.80E-09	1.30E-10	4.62E-09	5.60E-15	4.75E-09
Chlorobenzene	0.00042	4.78E-10	2.34E-09	1.43E-15	2.82E-09	1.08E-09	1.25E-08	2.05E-14	1.36E-08	4.65E-10	1.65E-08	2.00E-14	1.70E-08
Chloroform	0.00042	4.78E-10	2.34E-09	1.43E-15	2.82E-09	1.08E-09	1.25E-08	2.05E-14	1.36E-08	4.65E-10	1.65E-08	2.00E-14	1.70E-08
Endrin	0.00005	5.74E-11	2.81E-10	1.71E-16	3.38E-10	1.30E-10	1.50E-09	2.46E-15	1.63E-09	5.58E-11	1.98E-09	2.40E-15	2.04E-09
gamma BHC	0.00003	3.82E-11	1.87E-10	1.14E-16	2.26E-10	8.68E-11	9.98E-10	1.64E-15	1.08E-09	3.72E-11	1.32E-09	1.60E-15	1.36E-09
Heptachlor	0.00003	2.87E-11	1.40E-10	8.57E-17	1.69E-10	6.51E-11	7.48E-10	1.23E-15	8.13E-10	2.79E-11	9.90E-10	1.20E-15	1.02E-09
Heptachlor epoxide	0.00070	7.94E-10	3.89E-09	2.37E-15	4.68E-09	1.80E-09	2.07E-08	3.41E-14	2.25E-08	7.72E-10	2.74E-08	3.32E-14	2.82E-08
Hexachlorobenzene	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08
Hexachlorobutadiene	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08
Hexachloroethane	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08
m&p Cresol	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08
Methl ethyl ketone	0.00848	9.56E-09	4.68E-08	2.86E-14	5.64E-08	2.17E-08	2.49E-07	4.10E-13	2.71E-07	9.30E-09	3.30E-07	4.00E-13	3.39E-07
Methoxychlor	0.00153	1.72E-09	8.43E-09	5.14E-15	1.01E-08	3.90E-09	4.49E-08	7.39E-14	4.88E-08	1.67E-09	5.94E-08	7.20E-14	6.11E-08
Nitrobenzene	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08
o-Cresol	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08
Pentachlorophenol	0.00424	4.78E-09	2.34E-08	1.43E-14	2.82E-08	1.08E-08	1.25E-07	2.05E-13	1.36E-07	4.65E-09	1.65E-07	2.00E-13	1.70E-07
Pyridine	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08
Tetrachloroethene	0.00042	4.78E-10	2.34E-09	1.43E-15	2.82E-09	1.08E-09	1.25E-08	2.05E-14	1.36E-08	4.65E-10	1.65E-08	2.00E-14	1.70E-08
Toxaphene	0.00204	2.29E-09	1.12E-08	6.86E-15	1.35E-08	5.21E-09	5.99E-08	9.85E-14	6.51E-08	2.23E-09	7.92E-08	9.60E-14	8.14E-08
Trichloroethene	0.00042	4.78E-10	2.34E-09	1.43E-15	2.82E-09	1.08E-09	1.25E-08	2.05E-14	1.36E-08	4.65E-10	1.65E-08	2.00E-14	1.70E-08
Vinyl chloride	0.00085	9.56E-10	4.68E-09	2.86E-15	5.64E-09	2.17E-09	2.49E-08	4.10E-14	2.71E-08	9.30E-10	3.30E-08	4.00E-14	3.39E-08

Table 4. Applicable Criteria and Toxicological Endpoints for the Protection of Human Health

	CDPHE Standards (mg/L)	RfD (water) (mg/kg/d)	RfD (mg/kg/d)	Inhalation Unit Risk (ug/m3)-1	Slope Factor (mg/kg/d)-1	WOE	EPA Soil Screening Level (mg/kg)
Inorganics:							
Arsenic	0.05	NA	3.0E-04	4.3E-03	1.5E+00	A	15
Barium	2	NA	7.0E-02	NA	NA	NA	32
Cadmium	0.005	5.00E-04	1.0E-03	1.8E-03	6.3E+00	B1	6
Chromium	0.1	NA	1.0E+00	NA	NA	NA	19
Cyanide	0.2	NA	2.0E-02	NA	NA	D	NA
Lead	0.05	NA	NA	NA	NA	B2	NA
Mercury	0.002	NA	3.0E-04	NA	NA	C	3
Nickel	0.1	NA	2.0E-02	NA	NA	NA	21
Selenium	0.05	NA	5.0E-03	NA	NA	D	3
Silver	0.05	NA	5.0E-03	NA	NA	D	NA
Thallium	0.002	NA	8.0E-05	NA	NA	D	0.4
Organics:							
1,1 Dichloroethene	NA	NA	9.0E-03	5.0E-05	6.0E-01	C	0.03
1,2 Dichloroethane	0.0004	NA	NA	2.6E-05	9.1E-02	B2	0.01
1.4 Dichlorobenzene	0.075	NA	8.0E-01	NA	NA	NA	1
2,4 D	0.07	NA	1.0E-02	NA	NA	NA	NA
2,4 Dintirotoluene	0.014	NA	2.0E-03	NA	NA	NA	0.2
2,4,5 TP	0.05	NA	8.0E-03	NA	NA	D	NA
2,4,5 Trichlorophenol	NA	NA	1.0E-01	NA	NA	NA	120
2,4,6 Trichlorophenol	0.002	NA	NA	3.1E-06	1.1E-02	B2	0.06
Benzene	0.005	NA	NA	8.3E-06	2.9E-02	A	0.02
Carbon tetrachloride	0.0003	NA	7.0E-04	1.5E-05	1.3E-01	B2	0.03
Chlordane	0.00003	NA	6.5E-05	3.7E-04	1.3E+00	B2	2
Chlorobenzene	0.1	NA	2.0E-02	NA	NA	D	0.6
Chloroform	0.006	NA	1.0E-02	2.3E-05	6.1E-03	B2	0.3
Endrin	0.002	NA	3.0E-04	NA	NA	D	0.4
gamma BHC	0.0002	NA	3.0E-04	NA	NA	NA	0.006
Heptachlor	0.000008	NA	5.0E-04	1.3E-03	4.5E+00	B2	0.06
Heptachlor epoxide	0.000004	NA	1.3E-05	2.6E-03	9.1E+00	B2	0.03
Hexachlorobenzene	0.001	NA	8.0E-04	4.6E-04	1.6E+00	B2	0.8
Hexachlorobutadiene	0.001	NA	NA	2.2E-05	7.8E-02	C	0.1
Hexachloroethane	NA	NA	1.0E-03	4.0E-06	1.4E-02	C	0.2
m&p Cresol	NA	NA	NA	NA	NA	NA	NA
Methl ethyl ketone	NA	NA	6.0E-01	NA	NA	D	NA
Methoxychlor	0.04	NA	5.0E-03	NA	NA	D	62
Nitrobenzene	0.0035	NA	5.0E-04	NA	NA	D	0.09
o-Cresol	NA	NA	NA	NA	NA	NA	6
Pentachlorophenol	0.001	NA	3.0E-02	NA	1.2E-01	B2	0.01
Pyridine	NA	NA	1.0E-03	NA	NA	NA	NA
Tetrachloroethene	NA	NA	1.0E-02	NA	NA	NA	0.04
Toxaphene	0.00003	NA	NA	3.2E-04	1.1E+00	B2	0.04
Trichloroethene	NA	NA	NA	NA	NA	NA	0.02
Vinyl chloride	0.002	NA	NA	NA	1.9E+00	A	0.01

Notes:

** The cadmium slope factor was back-calculated from the inhalation unit risk with Equation 9 and does not apply to oral exposures.*

The Soil Screening Level (SSL) pertains to the protection of groundwater with a DAF of 10.

Toxicity values do not apply for lead; EPA has propagated a soil value of 400 mg/kg based on the IUBK model (EPA, 1994b).

WOE - Weight of Evidence Rating for cancer risk

A - known human carcinogen

B1 - probable human carcinogen; evidence from human and animal studies

B2 - probable human carcinogen; animal evidence only

C - possible human carcinogen

D - not classifiable as to carcinogenicity in humans

m-Cresol=3-methylphenol; o-Cresol=2 methylphenol; p-Cresol=4 methylphenol

NA - Not Available

Source:

CDPHE Standards	*Compass, 1996*
RfD	*EPA, 1997; EPA, 1994a*
Slope Factor	*EPA, 1997; EPA, 1994a*
SSL	*EPA, 1994b*

Table 5. Cancer and Noncancer Health Risks for Each Human Health Exposure Scenario (1 of 4).

Scenario: Cancer Risk - Contact Directly with Leachate

	Worker (mg/kg/d)				Resident - Child (mg/kg/d)				Resident - Adult (mg/kg/d)			
Analyte	**Leachate Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**
Inorganics:												
Arsenic	4.43E-07	2.08E-06	NA	2.52E-06								
Barium	No Tox Value	No Tox Value	NA	0.00E+00								
Cadmium	No Tox Value	No Tox Value	NA	0.00E+00								
Chromium	No Tox Value	No Tox Value	NA	0.00E+00								
Cyanide	No Tox Value	No Tox Value	NA	0.00E+00								
Lead	No Tox Value	No Tox Value	NA	0.00E+00								
Mercury	No Tox Value	No Tox Value	NA	0.00E+00								
Nickel	No Tox Value	No Tox Value	NA	0.00E+00								
Selenium	No Tox Value	No Tox Value	NA	0.00E+00								
Silver	No Tox Value	No Tox Value	NA	0.00E+00								
Thallium	No Tox Value	No Tox Value	NA	0.00E+00								
Organics:												
Benzene	3.89E-10	3.84E-08	NA	3.88E-08								
1,1 Dichloroethene	4.03E-08	3.03E-06	NA	3.07E-06								
1,2 Dichloroethane	6.11E-09	1.52E-07	NA	1.58E-07								
1 4 Dichlorobenzene	No Tox Value	No Tox Value	NA	0.00E+00								
2,4 D	No Tox Value	No Tox Value	NA	0.00E+00								
2,4 Dintirotoluene	No Tox Value	No Tox Value	NA	0.00E+00								
2,4,5 TP	No Tox Value	No Tox Value	NA	0.00E+00								
2,4,5 Trichlorophenol	No Tox Value	No Tox Value	NA	0.00E+00								
2,4,6 Trichlorophenol	1.48E-09	3.47E-07	NA	3.48E-07								
Carbon tetrachloride	8.72E-09	9.02E-07	NA	9.11E-07								
Chlordane	2.44E-08	5.97E-06	NA	5.99E-06								
Chlorobenzene	No Tox Value	No Tox Value	NA	0.00E+00								
Chloroform	4.09E-10	1.71E-08	NA	1.75E-08								
Endrin	No Tox Value	No Tox Value	NA	0.00E+00								
gamma BHC	No Tox Value	No Tox Value	NA	0.00E+00								
Heptachlor	1 81E-08	9.37E-07	NA	9.55E-07								
Heptachlor epoxide	1.01E-06	5.24E-05	NA	5.34E-05								
Hexachlorobenzene	2.15E-07	2.12E-04	NA	2.12E-04								
Hexachlorobutadiene	1.05E-08	5.90E-06	NA	5.91E-06								
Hexachloroethane	1 88E-09	3.71E-07	NA	3.73E-07								
m&p Cresol	No Tox Value	No Tox Value	NA	0.00E+00								
Methl ethyl ketone	No Tox Value	No Tox Value	NA	0.00E+00								
Methoxychlor	No Tox Value	No Tox Value	NA	0.00E+00								
Nitrobenzene	No Tox Value	No Tox Value	NA	0.00E+00								
o-Cresol	No Tox Value	No Tox Value	NA	0.00E+00								
Pentachlorophenol	8 05E-08	2.46E-04	NA	2.46E-04								
Pyridine	No Tox Value	No Tox Value	NA	0.00E+00								
Tetrachloroethene	No Tox Value	No Tox Value	NA	0.00E+00								
Toxaphene	3.54E-07	2.50E-05	NA	2.53E-05								
Trichloroethene	No Tox Value	No Tox Value	NA	0.00E+00								
Vinyl chloride	2.55E-07	8.75E-06	NA	9.00E-06								

Residential pathways not applicable for contact with leachate as this is not a current use.

Table 5. Cancer and Noncancer Health Risks for Each Human Health Exposure Scenario (2 of 4).

Scenario: Cancer Risk - Contact with Soils to Which Leachate Applied

	Worker (mg/kg/d)				Resident - Child (mg/kg/d)				Resident - Adult (mg/kg/d)			
Analyte	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**
Inorganics:												
Arsenic	4.51E-10	2.21E-09	1.35E-15	2.66E-09	3.07E-09	3.53E-08	5.80E-14	3.83E-08	1.31E-09	4.67E-08	5.66E-14	4.80E-08
Barium	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Cadmium	No Tox Value	No Tox Value	4.11E-15	4.11E-15	No Tox Value	No Tox Value	1.77E-13	1.77E-13	No Tox Value	No Tox Value	1.73E-13	1.73E-13
Chromium	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Cyanide	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Lead	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Mercury	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Nickel	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Selenium	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Silver	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Thallium	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Organics:												
Benzene	3.96E-13	1.94E-12	1.18E-18	2.34E-12	2.70E-12	3.10E-11	5.10E-17	3.37E-11	1.16E-12	4.10E-11	4.97E-17	4.22E-11
1,1 Dichloroethene	4.10E-11	2.01E-10	1.22E-16	2.42E-10	2.79E-10	3.21E-09	5.28E-15	3.49E-09	1.20E-10	4.24E-09	5.14E-15	4.36E-09
1,2 Dichloroethane	6.22E-12	3.04E-11	1.86E-17	3.66E-11	4.23E-11	4.86E-10	8.00E-16	5.29E-10	1.81E-11	6.44E-10	7.80E-16	6.62E-10
1 4 Dichlorobenzene	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
2,4 D	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
2,4 Dintirotoluene	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
2,4,5 TP	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
2,4,5 Trichlorophenol	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
2,4,6 Trichlorophenol	1.50E-12	7.36E-12	4.49E-18	8.86E-12	1.02E-11	1.18E-10	1.93E-16	1.28E-10	4.38E-12	1.56E-10	1.89E-16	1.60E-10
Carbon tetrachloride	8.88E-12	4.35E-11	2.65E-17	5.24E-11	6.04E-11	6.95E-10	1.14E-15	7.55E-10	2.59E-11	9.19E-10	1.11E-15	9.45E-10
Chlordane	2.49E-11	1.22E-10	7.43E-17	1.47E-10	1.69E-10	1.95E-09	3.20E-15	2.11E-09	7.25E-11	2.57E-09	3.12E-15	2.65E-09
Chlorobenzene	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Chloroform	4.17E-13	2.04E-12	1.24E-18	2.46E-12	2.84E-12	3.26E-11	5.36E-17	3.54E-11	1.22E-12	4.31E-11	5.23E-17	4.44E-11
Endrin	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
gamma BHC	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Heptachlor	1.84E-11	9.03E-11	5.51E-17	1.09E-10	1.26E-10	1.44E-09	2.37E-15	1.57E-09	5.38E-11	1.91E-09	2.31E-15	1.96E-09
Heptachlor epoxide	1.03E-09	5.05E-09	3.08E-15	6.08E-09	7.02E-09	8.08E-08	1.33E-13	8.78E-08	3.01E-09	1.07E-07	1.29E-13	1.10E-07
Hexachlorobenzene	2.19E-10	1.07E-09	6.53E-16	1.29E-09	1.49E-09	1.71E-08	2.81E-14	1.86E-08	6.37E-10	2.26E-08	2.74E-14	2.33E-08
Hexachlorobutadiene	1.07E-11	5.22E-11	3.18E-17	6.28E-11	7.25E-11	8.34E-10	1.37E-15	9.06E-10	3.11E-11	1.10E-09	1.34E-15	1.13E-09
Hexachloroethane	1.91E-12	9.36E-12	5.71E-18	1.13E-11	1.30E-11	1.50E-10	2.46E-16	1.63E-10	5.58E-12	1.98E-10	2.40E-16	2.04E-10
m&p Cresol	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Methl ethyl ketone	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Methoxychlor	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Nitrobenzene	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
o-Cresol	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Pentachlorophenol	8.20E-11	4.01E-10	2.45E-16	4.83E-10	5.58E-10	6.41E-09	1.06E-14	6.97E-09	2.39E-10	8.49E-09	1.03E-14	8.73E-09
Pyridine	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Tetrachloroethene	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Toxaphene	3.61E-10	1.77E-09	1.08E-15	2.13E-09	2.45E-09	2.82E-08	4.64E-14	3.07E-08	1.05E-09	3.73E-08	4.53E-14	3.84E-08
Trichloroethene	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Vinyl chloride	2.60E-10	1.27E-09	7.75E-16	1.53E-09	1.77E-09	2.03E-08	3.34E-14	2.21E-08	7.57E-10	2.69E-08	3.26E-14	2.76E-08

Table 5. Cancer and Noncancer Health Risks for Each Human Health Exposure Scenario (3 of 4).

Scenario: Noncancer Risk - Contact Directly with Leachate

	Worker (mg/kg/d)				Resident - Child (mg/kg/d)				Resident - Adult (mg/kg/d)			
Analyte	**Leachate Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**
Inorganics:												
Arsenic	6.89E-03	3.24E-02	NA	3.93E-02								
Barium	1.88E-04	8.83E-04	NA	1.07E-03								
Cadmium	3.01E-03	7.06E-03	NA	1.01E-02								
Chromium	5.64E-07	2.65E-06	NA	3.21E-06								
Cyanide	2.63E-04	1.24E-03	NA	1.50E-03								
Lead	No Tox Value	No Tox Value	NA	0.00E+00								
Mercury	8.77E-04	4.12E-03	NA	5.00E-03								
Nickel	4.79E-04	2.25E-03	NA	2.73E-03								
Selenium	1.13E-03	5.30E-03	NA	6.43E-03								
Silver	6.01E-04	2.83E-03	NA	3.43E-03								
Thallium	7.05E-02	3.31E-01	NA	4.02E-01								
Organics:												
Benzene	No Tox Value	No Tox Value	NA	0.00E+00								
1,1 Dichloroethene	5.22E-05	5.61E-04	NA	6.13E-04								
1,2 Dichloroethane	No Tox Value	No Tox Value	NA	0.00E+00								
1,4 Dichlorobenzene	1.17E-06	4.89E-05	NA	5.01E-05								
2,4 D	4.70E-04	3.15E-03	NA	3.62E-03								
2,4 Dintirotoluene	4.70E-04	1.20E-03	NA	1.67E-03								
2,4,5 TP	1.17E-04	7.88E-04	NA	9.06E-04								
2,4,5 Trichlorophenol	9.39E-06	6.37E-03	NA	6.38E-03								
2,4,6 Trichlorophenol	No Tox Value	No Tox Value	NA	0.00E+00								
Carbon tetrachloride	6.71E-04	9.91E-03	NA	1.06E-02								
Chlordane	2.02E-03	7.06E-02	NA	7.27E-02								
Chlorobenzene	2.35E-05	6.46E-04	NA	6.70E-04								
Chloroform	4.70E-05	2.81E-04	NA	3.28E-04								
Endrin	1.88E-04	2.02E-03	NA	2.21E-03								
gamma BHC	1.25E-04	1.18E-03	NA	1.30E-03								
Heptachlor	5.64E-05	4.16E-04	NA	4.73E-04								
Heptachlor epoxide	6.00E-02	4.43E-01	NA	5.03E-01								
Hexachlorobenzene	1.17E-03	1.66E-01	NA	1.67E-01								
Hexachlorobutadiene	No Tox Value	No Tox Value	NA	0.00E+00								
Hexachloroethane	9.39E-04	2.65E-02	NA	2.74E-02								
m&p Cresol	No Tox Value	No Tox Value	NA	0.00E+00								
Methl ethyl ketone	1.57E-05	1.16E-05	NA	2.72E-05								
Methoxychlor	3.38E-04	2.27E-03	NA	2.61E-03								
Nitrobenzene	1.88E-03	1.26E-02	NA	1.45E-02								
o-Cresol	No Tox Value	No Tox Value	NA	0.00E+00								
Pentachlorophenol	1.57E-04	6.83E-02	NA	6.85E-02								
Pyridine	9.39E-04	6.31E-03	NA	7.25E-03								
Tetrachloroethene	4.70E-05	1.51E-03	NA	1.56E-03								
Toxaphene	No Tox Value	No Tox Value	NA	0.00E+00								
Trichloroethene	No Tox Value	No Tox Value	NA	0.00E+00								
Vinyl chloride	No Tox Value	No Tox Value	NA	0.00E+00								

Residential pathways not applicable for contact with leachate as this is not a current use.

Table 5. Cancer and Noncancer Health Risks for Each Human Health Exposure Scenario (4 of 4).

Scenario: Noncancer Risk - Contact with Soils to Which Leachate Applied

	Worker (mg/kg/d)				Resident - Child (mg/kg/d)				Resident - Adult (mg/kg/d)			
Analyte	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**	**Soil Ingestion**	**Dermal Contact**	**Inhalation**	**Total**
Inorganics:												
Arsenic	7.01E-06	3.43E-05	2.10E-11	4.13E-05	1.59E-05	1.83E-04	3.01E-10	1.99E-04	6.82E-06	2.42E-04	2.93E-10	2.49E-04
Barium	1.91E-07	9.36E-07	5.71E-13	1.13E-06	4.34E-07	4.99E-06	8.21E-12	5.42E-06	1.86E-07	6.60E-06	8.00E-12	6.79E-06
Cadmium	1.53E-06	7.49E-06	4.57E-12	9.02E-06	3.47E-06	3.99E-05	6.57E-11	4.34E-05	1.49E-06	5.28E-05	6.40E-11	5.43E-05
Chromium	5.74E-10	2.81E-09	1.71E-15	3.38E-09	1.30E-09	1.50E-08	2.46E-14	1.63E-08	5.58E-10	1.98E-08	2.40E-14	2.04E-08
Cyanide	2.68E-07	1.31E-06	8.00E-13	1.58E-06	6.07E-07	6.98E-06	1.15E-11	7.59E-06	2.60E-07	9.24E-06	1.12E-11	9.50E-06
Lead	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Mercury	8.92E-07	4.37E-06	2.67E-12	5.26E-06	2.02E-06	2.33E-05	3.83E-11	2.53E-05	8.68E-07	3.08E-05	3.73E-11	3.17E-05
Nickel	4.88E-07	2.39E-06	1.46E-12	2.88E-06	1.11E-06	1.27E-05	2.09E-11	1.38E-05	4.74E-07	1.68E-05	2.04E-11	1.73E-05
Selenium	1.15E-06	5.62E-06	3.43E-12	6.77E-06	2.60E-06	2.99E-05	4.93E-11	3.25E-05	1.12E-06	3.96E-05	4.80E-11	4.07E-05
Silver	6.12E-07	3.00E-06	1.83E-12	3.61E-06	1.39E-06	1.60E-05	2.63E-11	1.74E-05	5.95E-07	2.11E-05	2.56E-11	2.17E-05
Thallium	7.17E-05	3.51E-04	2.14E-10	4.23E-04	1.63E-04	1.87E-03	3.08E-09	2.03E-03	6.97E-05	2.48E-03	3.00E-09	2.54E-03
Organics:												
Benzene	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
1,1 Dichloroethene	5.31E-08	2.60E-07	1.59E-13	3.13E-07	1.21E-07	1.39E-06	2.28E-12	1.51E-06	5.16E-08	1.83E-06	2.22E-12	1.89E-06
1,2 Dichloroethane	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
1 4 Dichlorobenzene	1.20E-09	5.85E-09	3.57E-15	7.05E-09	2.71E-09	3.12E-08	5.13E-14	3.39E-08	1.16E-09	4.13E-08	5.00E-14	4.24E-08
2,4 D	4.78E-07	2.34E-06	1.43E-12	2.82E-06	1.08E-06	1.25E-05	2.05E-11	1.36E-05	4.65E-07	1.65E-05	2.00E-11	1.70E-05
2,4 Dintirotoluene	4.78E-07	2.34E-06	1.43E-12	2.82E-06	1.08E-06	1.25E-05	2.05E-11	1.36E-05	4.65E-07	1.65E-05	2.00E-11	1.70E-05
2,4,5 TP	1.20E-07	5.85E-07	3.57E-13	7.05E-07	2.71E-07	3 12E-06	5.13E-12	3.39E-06	1.16E-07	4.13E-06	5.00E-12	4.24E-06
2,4,5 Trichlorophenol	9.56E-09	4.68E-08	2.86E-14	5.64E-08	2.17E-08	2.49E-07	4.10E-13	2.71E-07	9.30E-09	3.30E-07	4.00E-13	3.39E-07
2,4,6 Trichlorophenol	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Carbon tetrachloride	6.83E-07	3.34E-06	2.04E-12	4.03E-06	1.55E-06	1.78E-05	2.93E-11	1.94E-05	6.64E-07	2.36E-05	2.86E-11	2.42E-05
Chlordane	2.06E-06	1.01E-05	6.15E-12	1.21E-05	4.67E-06	5.37E-05	8.84E-11	5.84E-05	2.00E-06	7.11E-05	8.61E-11	7.31E-05
Chlorobenzene	2.39E-08	1.17E-07	7.14E-14	1.41E-07	5.42E-08	6.24E-07	1.03E-12	6.78E-07	2.32E-08	8.25E-07	1.00E-12	8.48E-07
Chloroform	4.78E-08	2.34E-07	1.43E-13	2.82E-07	1.08E-07	1.25E-06	2.05E-12	1.36E-06	4.65E-08	1.65E-06	2.00E-12	1.70E-06
Endrin	1.91E-07	9.36E-07	5.71E-13	1.13E-06	4.34E-07	4.99E-06	8.21E-12	5.42E-06	1.86E-07	6.60E-06	8.00E-12	6.79E-06
gamma BHC	1.27E-07	6.24E-07	3.81E-13	7.52E-07	2.89E-07	3.33E-06	5.47E-12	3.62E-06	1.24E-07	4.40E-06	5.33E-12	4.52E-06
Heptachlor	5.74E-08	2.81E-07	1.71E-13	3.38E-07	1.30E-07	1.50E-06	2.46E-12	1.63E-06	5.58E-08	1.98E-06	2.40E-12	2.04E-06
Heptachlor epoxide	6.11E-05	2.99E-04	1.82E-10	3.60E-04	1.38E-04	1.59E-03	2.62E-09	1.73E-03	5.94E-05	2.11E-03	2.55E-09	2.17E-03
Hexachlorobenzene	1.20E-06	5.85E-06	3.57E-12	7.05E-06	2.71E-06	3.12E-05	5.13E-11	3.39E-05	1.16E-06	4.13E-05	5.00E-11	4.24E-05
Hexachlorobutadiene	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Hexachloroethane	9 56E-07	4.68E-06	2.86E-12	5.64E-06	2.17E-06	2.49E-05	4.10E-11	2.71E-05	9.30E-07	3.30E-05	4.00E-11	3.39E-05
m&p Cresol	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Methl ethyl ketone	1.59E-08	7.80E-08	4.76E-14	9.40E-08	3.62E-08	4.16E-07	6.84E-13	4.52E-07	1.55E-08	5.50E-07	6.67E-13	5.66E-07
Methoxychlor	3.44E-07	1.69E-06	1.03E-12	2.03E-06	7.81E-07	8.98E-06	1 48E-11	9.76E-06	3.35E-07	1.19E-05	1.44E-11	1.22E-05
Nitrobenzene	1.91E-06	9.36E-06	5.71E-12	1.13E-05	4.34E-06	4.99E-05	8.21E-11	5.42E-05	1.86E-06	6 60E-05	8.00E-11	6.79E-05
o-Cresol	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Pentachlorophenol	1.59E-07	7.80E-07	4.76E-13	9.40E-07	3.62E-07	4.16E-06	6.84E-12	4.52E-06	1.55E-07	5.50E-06	6.67E-12	5.66E-06
Pyridine	9.56E-07	4.68E-06	2.86E-12	5.64E-06	2.17E-06	2.49E-05	4.10E-11	2.71E-05	9.30E-07	3.30E-05	4.00E-11	3.39E-05
Tetrachloroethene	4.78E-08	2.34E-07	1.43E-13	2.82E-07	1.08E-07	1.25E-06	2.05E-12	1.36E-06	4.65E-08	1.65E-06	2.00E-12	1.70E-06
Toxaphene	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Trichloroethene	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00
Vinyl chloride	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00	No Tox Value	No Tox Value	No Tox Value	0.00E+00

Table 6. Data Used to Develop Exposure Parameters for Terrestrial Receptors (EPA, 1993; Beyer et al., 1994)

Receptor	Summary Statistics	Body Weight [BW] (kg)	Surface Area [SA] (cm2/d)	Dietary Ingestion Rate [DIR] (kg/kg bw/d)	Water Ingestion Rate [WIR] (L/kg bw/d)	Home Range [HR] (ha)	Soil % in Diet [SF]
American Robin	Minimum	0.06	182	0.75	0.14	0.11	9.3
	Maximum	0.0862	198	1.52	0.14	0.42	10.4
	95th percentile	0.08	197	1.46	0.14	0.38	10.3
Deer Mouse	Minimum	0.01	86	0.07	0.056	0.0075	2.4
	Maximum	0.0315	91	0.45	0.34	0.94	2.4
	95th percentile	0.03	91	0.37	0.25	0.42	2.4

Table 7. Exposure Intakes for Terrestrial Receptors.

Analyte	Leachate EPC (mg/L)	Soil EPC (mg/kg)	American Robin				Deer Mouse			
			Drinking (mg/kg bw/d)	Soil Ingestion (mg/kg bw/d)	Dermal Contact (mg/kg bw/d)	Total	Drinking (mg/kg bw/d)	Soil Ingestion (mg/kg bw/d)	Dermal Contact (mg/kg bw/d)	Total
Inorganics:										
Arsenic	0.110	0.002	1.54E-02	2.81E-04	3.35E-06	1.57E-02	2.76E-02	1.67E-05	6.05E-06	2.77E-02
Barium	0.700	0.012	9.80E-02	1.79E-03	2.13E-05	9.98E-02	1.76E-01	1.06E-04	3.85E-05	1.76E-01
Cadmium	0.080	0.001	1.12E-02	2.05E-04	2.43E-06	1.14E-02	2.01E-02	1.21E-05	4.40E-06	2.01E-02
Chromium	0.030	0.001	4.20E-03	7.67E-05	9.12E-07	4.28E-03	7.54E-03	4.54E-06	1.65E-06	7.54E-03
Cyanide	0.280	0.005	3.92E-02	7.16E-04	8.52E-06	3.99E-02	7.03E-02	4.24E-05	1.54E-05	7.04E-02
Lead	0.100	0.002	1.40E-02	2.56E-04	3.04E-06	1.43E-02	2.51E-02	1.51E-05	5.50E-06	2.51E-02
Mercury	0.014	0.0002	1.96E-03	3.58E-05	4.26E-07	2.00E-03	3.52E-03	2.12E-06	7.70E-07	3.52E-03
Nickel	0.510	0.009	7.14E-02	1.30E-03	1.55E-05	7.27E-02	1.28E-01	7.73E-05	2.80E-05	1.28E-01
Selenium	0.300	0.005	4.20E-02	7.67E-04	9.12E-06	4.28E-02	7.54E-02	4.54E-05	1.65E-05	7.54E-02
Silver	0.160	0.003	2.24E-02	4.09E-04	4.87E-06	2.28E-02	4.02E-02	2.42E-05	8.80E-06	4.02E-02
Thallium	0.300	0.005	4.20E-02	7.67E-04	9.12E-06	4.28E-02	7.54E-02	4.54E-05	1.65E-05	7.54E-02
Organics:										
Benzene	0.005	0.00008	7.00E-04	1.28E-05	1.52E-07	7.13E-04	1.26E-03	7.57E-07	2.75E-07	1.26E-03
1,1 Dichloroethene	0.025	0.00042	3.50E-03	6.39E-05	7.60E-07	3.56E-03	6.28E-03	3.79E-06	1.37E-06	6.29E-03
1,2 Dichloroethane	0.025	0.00042	3.50E-03	6.39E-05	7.60E-07	3.56E-03	6.28E-03	3.79E-06	1.37E-06	6.29E-03
1.4 Dichlorobenzene	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02
2,4 D	0.250	0.00424	3.50E-02	6.39E-04	7.60E-06	3.56E-02	6.28E-02	3.79E-05	1.37E-05	6.29E-02
2,4 Dintirotoluene	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02
2,4,5 TP	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02
2,4,5 Trichlorophenol	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02
2,4,6 Trichlorophenol	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02
Carbon tetrachloride	0.025	0.00042	3.50E-03	6.39E-05	7.60E-07	3.56E-03	6.28E-03	3.79E-06	1.37E-06	6.29E-03
Chlordane	0.007	0.00012	9.80E-04	1.79E-05	2.13E-07	9.98E-04	1.76E-03	1.06E-06	3.85E-07	1.76E-03
Chlorobenzene	0.025	0.00042	3.50E-03	6.39E-05	7.60E-07	3.56E-03	6.28E-03	3.79E-06	1.37E-06	6.29E-03
Chloroform	0.025	0.00042	3.50E-03	6.39E-05	7.60E-07	3.56E-03	6.28E-03	3.79E-06	1.37E-06	6.29E-03
Endrin	0.003	0.00005	4.20E-04	7.67E-06	9.12E-08	4.28E-04	7.54E-04	4.54E-07	1.65E-07	7.54E-04
gamma BHC	0.002	0.00003	2.80E-04	5.11E-06	6.08E-08	2.85E-04	5.02E-04	3.03E-07	1.10E-07	5.03E-04
Heptachlor	0.002	0.00003	2.10E-04	3.84E-06	4.56E-08	2.14E-04	3.77E-04	2.27E-07	8.25E-08	3.77E-04
Heptachlor epoxide	0.042	0.00070	5.81E-03	1.06E-04	1.26E-06	5.92E-03	1.04E-02	6.29E-06	2.28E-06	1.04E-02
Hexachlorobenzene	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02
Hexachlorobutadiene	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02
Hexachloroethane	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02
m&p Cresol	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02
Methl ethyl ketone	0.500	0.00848	7.00E-02	1.28E-03	1.52E-05	7.13E-02	1.26E-01	7.57E-05	2.75E-05	1.26E-01
Methoxychlor	0.090	0.00153	1.26E-02	2.30E-04	2.74E-06	1.28E-02	2.26E-02	1.36E-05	4.95E-06	2.26E-02
Nitrobenzene	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02
o-Cresol	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02
Pentachlorophenol	0.250	0.00424	3.50E-02	6.39E-04	7.60E-06	3.56E-02	6.28E-02	3.79E-05	1.37E-05	6.29E-02
Pyridine	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02
Tetrachloroethene	0.025	0.00042	3.50E-03	6.39E-05	7.60E-07	3.56E-03	6.28E-03	3.79E-06	1.37E-06	6.29E-03
Toxaphene	0.120	0.00204	1.68E-02	3.07E-04	3.65E-06	1.71E-02	3.01E-02	1.82E-05	6.60E-06	3.02E-02
Trichloroethene	0.025	0.00042	3.50E-03	6.39E-05	7.60E-07	3.56E-03	6.28E-03	3.79E-06	1.37E-06	6.29E-03
Vinyl chloride	0.050	0.00085	7.00E-03	1.28E-04	1.52E-06	7.13E-03	1.26E-02	7.57E-06	2.75E-06	1.26E-02

Table 8. Applicable Toxicity Criteria for the Protection of Ecological Health

Analyte	AWQC (mg/L)		TBV-Bird (mg/kg bw/d)	TBV-Mammal (mg/kg bw/d)
Inorganics:				
Arsenic	0.19		14	0.8
Barium	0.0039		19.4	7.1
Cadmium	0.001	*h*	0.1	0.55
Chromium	0.18	*h*	1.3	6.7
Cyanide	0.0052		NA	0.03
Iron	1	*i*	390	100
Lead	0.0025	*h*	14.5	4
Mercury	0.0013		2.5	0.8
Nickel	0.16	*h*	29.1	52.7
Selenium	0.005		0.66	0.038
Silver	0.00012	*	29.1	65
Thallium	NA		0.2	0.1
Organics:				
Benzene	0.046		NA	130
1,1 Dichloroethene	0.047		NA	9
1,2 Dichloroethane	NA		NA	4.7
1.4 Dichlorobenzene	0.015		NA	5
2,4 D	NA		NA	1
2,4 Dintirotoluene	NA		NA	0.2
2,4,5 TP	NA		NA	0.8
2,4,5 Trichlorophenol	NA		NA	100
2,4,6 Trichlorophenol	NA		NA	NA
Carbon tetrachloride	NA		NA	0.7
Chlordane	NA		0.1	NA
Chlorobenzene	0.13		NA	19
Chloroform	NA		NA	0.4
Endrin	0.000061	*s*	0.032	0.03
gamma BHC	0.00008		0.3	0.33
Heptachlor	0.0000069	+	0.3	0.2
Heptachlor epoxide	NA		NA	0.01
Hexachlorobenzene	NA		NA	0.1
Hexachlorobutadiene	NA		NA	NA
Hexachloroethane	0.012		NA	1
m&p Cresol	NA		NA	NA
Methl ethyl ketone	NA		NA	50
Methoxychlor	0.000019		NA	28.6
Nitrobenzene	NA		NA	NA
o-Cresol	NA		NA	NA
Pentachlorophenol	0.013	*pH*	NA	3
Pyridine	NA		NA	1
Tetrachloroethene	0.12		NA	14
Toxaphene	0.000011		0.2	NA
Trichloroethene	0.35		NA	33.3
Vinyl chloride	NA		NA	NA

Notes:

Metal criteria are for total dissolved concentrations.

AWQC - Ambient Water Quality Criterion; Final Chronic Value, or Tier II Value; EPA, 1996

h = hardness dependent criterion; value based on hardness of 100 mg/L as CaCO3

i - instantaneous maximum

s - final chronic value derived for EPA sediment quality criteria documents

+ - value with EPA support documents

pH - pH dependent ambient water quality criterion (7.8 pH used in table)

** EPA, 1980. AWQC for Silver. Value currently withdrawn (EPA, 11/24/97)*

Cr and As AWQC are for the +(III) valences; Hg AWQC is for inorganic species

Source:

AWQC — *EPA, 1996; EPA, 1980*

TBV — *Appendix B lists details and references*

Table 9. Uncertainty Factors Used to Develop Toxicity Benchmarks for Ecological Receptors

Category	Description	UF
Intertaxon	Threatened & Endangered	2
	Same species	1
	Same genus	2
	Same family	3
	Same order	4
	Same class	5
Duration	Less than/equal to 14 days	10
	15-30 days	5
	> 30 days	1
Endpoint	LD50, LC50	10
	TDLo lethal	7
	TDLo sublethal	5
	NOAEL, lethal or LOAEL, nonlethal	3
	NOAEL, nonlethal	1

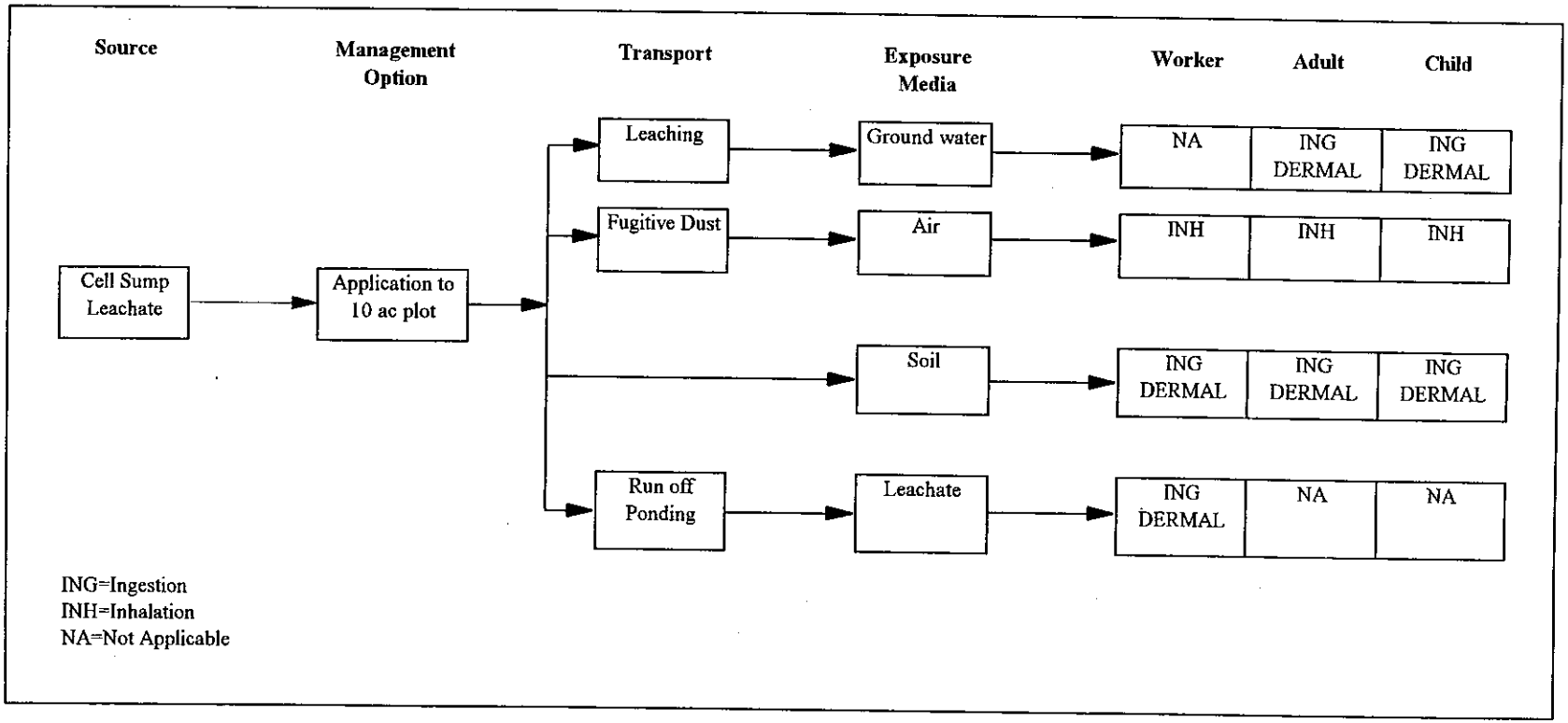
Table 10. Hazard Quotients for Aquatic and Terrestrial Receptors.

Analyte	Aquatic Life	American Robin				Deer Mouse			
		Drinking	Soil Ingestion	Dermal Contact	Total	Drinking	Soil Ingestion	Dermal Contact	Total
Inorganics:									
Arsenic	0.58	1.1E-03	2.0E-05	2.4E-07	1.1E-03	3.5E-02	2.1E-05	7.6E-06	3.5E-02
Barium	179.49	5.1E-03	9.2E-05	1.1E-06	5.1E-03	2.5E-02	1.5E-05	5.4E-06	2.5E-02
Cadmium	80.00	1.1E-01	2.0E-03	2.4E-05	1.1E-01	3.7E-02	2.2E-05	8.0E-06	3.7E-02
Chromium	0.17	3.2E-03	5.9E-05	7.0E-07	3.3E-03	1.1E-03	6.8E-07	2.5E-07	1.1E-03
Cyanide	53.85	No Tox Value	No Tox Value	No Tox Value	0.0E+00	2.3E+00	1.4E-03	5.1E-04	2.3E+00
Lead	40.00	9.7E-04	1.8E-05	2.1E-07	9.8E-04	6.3E-03	3.8E-06	1.4E-06	6.3E-03
Mercury	10.77	7.8E-04	1.4E-05	1.7E-07	8.0E-04	4.4E-03	2.7E-06	9.6E-07	4.4E-03
Nickel	3.19	2.5E-03	4.5E-05	5.3E-07	2.5E-03	2.4E-03	1.5E-06	5.3E-07	2.4E-03
Selenium	60.00	6.4E-02	1.2E-03	1.4E-05	6.5E-02	2.0E+00	1.2E-03	4.3E-04	2.0E+00
Silver	1333.33	7.7E-04	1.4E-05	1.7E-07	7.8E-04	6.2E-04	3.7E-07	1.4E-07	6.2E-04
Thallium	No Tox Value	2.1E-01	3.8E-03	4.6E-05	2.1E-01	7.5E-01	4.5E-04	1.6E-04	7.5E-01
Organics:									
Benzene	0.11	No Tox Value	No Tox Value	No Tox Value	0.0E+00	9.7E-06	5.8E-09	2.1E-09	9.7E-06
1,1 Dichloroethene	0.53	No Tox Value	No Tox Value	No Tox Value	0.0E+00	7.0E-04	4.2E-07	1.5E-07	7.0E-04
1,2 Dichloroethane	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	1.3E-03	8.1E-07	2.9E-07	1.3E-03
1.4 Dichlorobenzene	3.33	No Tox Value	No Tox Value	No Tox Value	0.0E+00	2.5E-03	1.5E-06	5.5E-07	2.5E-03
2,4 D	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	6.3E-02	3.8E-05	1.4E-05	6.3E-02
2,4 Dintirotoluene	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	6.3E-02	3.8E-05	1.4E-05	6.3E-02
2,4,5 TP	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	1.6E-02	9.5E-06	3.4E-06	1.6E-02
2,4,5 Trichlorophenol	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	1.3E-04	7.6E-08	2.7E-08	1.3E-04
2,4,6 Trichlorophenol	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	No Tox Value	No Tox Value	No Tox Value	0.0E+00
Carbon tetrachloride	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	9.0E-03	5.4E-06	2.0E-06	9.0E-03
Chlordane	No Tox Value	9.8E-03	1.8E-04	2.1E-06	1.0E-02	No Tox Value	No Tox Value	No Tox Value	0.0E+00
Chlorobenzene	0.19	No Tox Value	No Tox Value	No Tox Value	0.0E+00	3.3E-04	2.0E-07	7.2E-08	3.3E-04
Chloroform	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	1.6E-02	9.5E-06	3.4E-06	1.6E-02
Endrin	49.18	1.3E-02	2.4E-04	2.9E-06	1.3E-02	2.5E-02	1.5E-05	5.5E-06	2.5E-02
gamma BHC	25.00	9.3E-04	1.7E-05	2.0E-07	9.5E-04	1.5E-03	9.2E-07	3.3E-07	1.5E-03
Heptachlor	217.39	7.0E-04	1.3E-05	1.5E-07	7.1E-04	1.9E-03	1.1E-06	4.1E-07	1.9E-03
Heptachlor epoxide	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	1.0E+00	6.3E-04	2.3E-04	1.0E+00
Hexachlorobenzene	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	1.3E-01	7.6E-05	2.7E-05	1.3E-01
Hexachlorobutadiene	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	No Tox Value	No Tox Value	No Tox Value	0.0E+00
Hexachloroethane	4.17	No Tox Value	No Tox Value	No Tox Value	0.0E+00	1.3E-02	7.6E-06	2.7E-06	1.3E-02
m&p Cresol	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	No Tox Value	No Tox Value	No Tox Value	0.0E+00
Methl ethyl ketone	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	2.5E-03	1.5E-06	5.5E-07	2.5E-03
Methoxychlor	4736.84	No Tox Value	No Tox Value	No Tox Value	0.0E+00	7.9E-04	4.8E-07	1.7E-07	7.9E-04
Nitrobenzene	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	No Tox Value	No Tox Value	No Tox Value	0.0E+00
o-Cresol	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	No Tox Value	No Tox Value	No Tox Value	0.0E+00
Pentachlorophenol	19.23	No Tox Value	No Tox Value	No Tox Value	0.0E+00	2.1E-02	1.3E-05	4.6E-06	2.1E-02
Pyridine	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	1.3E-02	7.6E-06	2.7E-06	1.3E-02
Tetrachloroethene	0.21	No Tox Value	No Tox Value	No Tox Value	0.0E+00	4.5E-04	2.7E-07	9.8E-08	4.5E-04
Toxaphene	10909.09	8.4E-02	1.5E-03	1.8E-05	8.6E-02	No Tox Value	No Tox Value	No Tox Value	0.0E+00
Trichloroethene	0.07	No Tox Value	No Tox Value	No Tox Value	0.0E+00	1.9E-04	1.1E-07	4.1E-08	1.9E-04
Vinyl chloride	No Tox Value	No Tox Value	No Tox Value	No Tox Value	0.0E+00	No Tox Value	No Tox Value	No Tox Value	0.0E+00

5.2E-01

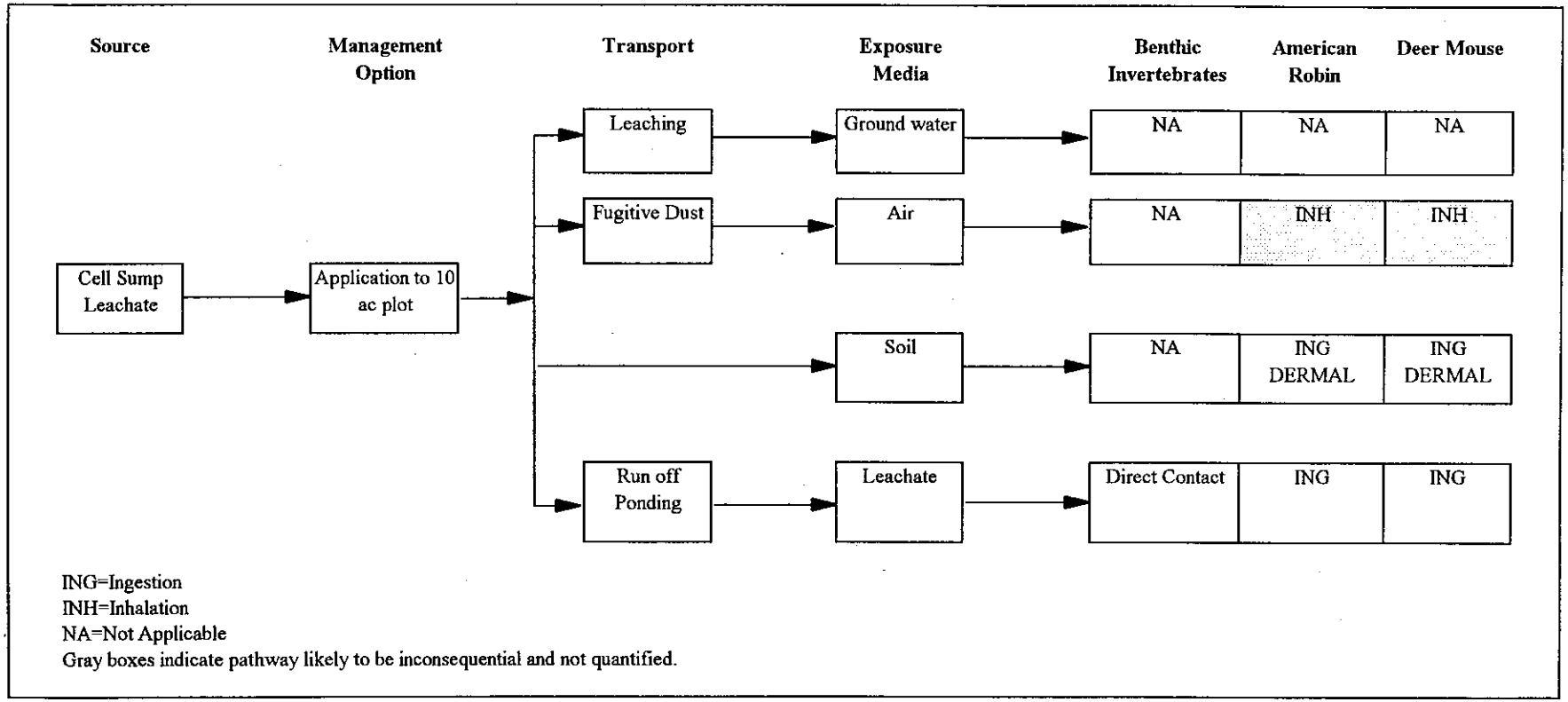
FIGURES

Figure 1. Conceptual Site Model



Note:For this analysis, the management option is considered the primary release mechanism under current risk assessment guidance.

Figure 2. Ecological Conceptual Site Model



Note: For this analysis, the management option is considered the primary release mechanism under current risk assessment guidance.

APPENDIX 1

RAW DATA

1.A DACWPF Sump Analytical
Summary for TCLP Metals

	Arsenic (mg/L)	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Lead (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)
1st Qtr '91	<0.05	0.3	0.03	<0.01	<0.05	<0.003	0.16	0.2	0.01	<0.1
2nd Qtr '91	<0.05	0.1	0.08	<0.01	<0.05	<0.003	0.38	0.2	0.01	<0.1
3rd Qtr '91	<0.05	0.2	0.04	<0.01	<0.05	<0.003	0.51	0.3	<0.01	0.2
4th Qtr '91	<0.05	0.1	0.04	<0.01	<0.05	0.012	0.18	0.1	<0.01	0.1
1st Qtr '92	<0.05	0.1	0.05	<0.01	<0.05	<0.003	0.18	0.2	<0.01	0.1
2nd Qtr '92	<0.05	<0.5	0.04	<0.01	<0.05	0.014	0.17	<0.1	<0.01	0.1
3rd Qtr '92	<0.05	<0.5	0.06	<0.01	<0.05	<0.003		0.2	<0.01	
4th Qtr '92	<0.05	<0.5	0.07	<0.01	<0.05	0.011	<0.04	0.2	<0.01	<0.1
1st Qtr '93	<0.05	<0.5	0.04	<0.01	<0.05	0.007	0.13	0.2	<0.01	0.1
2nd Qtr '93	<0.05	<0.5	0.03	<0.01	<0.05	0.01	0.32	<0.1	<0.01	0.3
3rd Qtr '93	<0.05	<0.5	0.01	<0.01	<0.01	0.009	0.15	<0.1	<0.01	0.2
4th Qtr '93	<0.05	<0.5	0.02	<0.01	<0.05	<0.003	<0.1	<0.01	0.16	<0.01
1st Qtr '94	<0.05	<0.5	0.03	<0.01	<0.05	0.008	0.2	<0.1	<0.01	0.2
2nd Qtr '94	<0.05	<0.5	0.04	<0.01	<0.05	0.003	0.17	<0.1	<0.01	<0.1
3rd Qtr '94	0.11	<0.5	0.03	0.03	<0.05	<0.003	0.15	0.2	0.02	<0.1
4th Qtr '94	<0.05	<0.5	0.03	<0.01	<0.05	0.009	0.18	0.1	<0.01	<0.1
1st Qtr '95	<0.05	<0.5	0.03	<0.01	<0.05	0.01	0.17	<0.1	<0.01	<0.1
2nd Qtr '95	0.1	<0.5	0.01	<0.01	<0.05	0.006	0.19	<0.1	<0.01	<0.1
3rd Qtr '95	<0.05	0.39	0.037	<0.01	<0.05	0.009	0.26	0.1	0.04	<0.1
4th Qtr '95	<0.05	<0.5	0.03	<0.01	<0.05	<0.002	0.17	<0.1	<0.01	<0.1
1st Qtr '96	<0.05	<0.5	0.03	<0.01	<0.05	<0.02	0.21	<0.1	<0.01	<0.1
2nd Qtr '96	<0.05	0.7	0.03	0.01	<0.05	<0.02	0.25	<0.1	0.01	<0.1
3rd Qtr '96	<0.05	<0.5	0.02	<0.01	<0.05	<0.02	0.16	<0.1	0.05	<0.1
4th Qtr '96	<0.05	0.5	0.03	<0.01	<0.05	<0.02	0.23	<0.1	0.01	<0.1
1st Qtr '97	<0.05	<0.5	0.03	<0.01	<0.05	<0.02	0.21	<0.1	<0.01	<0.1
2nd Qtr '97	<0.05	<0.5	0.04	<0.01	<0.05	0.006	0.34	<0.1	<0.01	<0.1
3rd Qtr '97	<0.05	<0.5	0.03	<0.01	<0.2	<0.02	0.2	<0.1	<0.01	<0.1
4th Qtr '97										

1.B. DACWPF Reconstructed Cell Sump Leachate Analytical Data - Summary of TOC, Cyanide, TOX, Oil and Grease, Total Suspended Solids, Iron, Silica, pH and Specific Conductivity

	TOC (mg/L)	Cyanide (mg/L)	TOX (ug/L (as Cl))	Oil & Grease (mg/L)	TSS (mg/L)	Iron, Total (mg/L)	Silica, Total (mg/L)	pH (pH units)	Specific Conductivity (umhos/cm)
1st Qtr '91	45	0.12	565	<5	<4	1.84	13.6	7.16	14,618
2nd Qtr '91	74	0.28	1170	<5	8	2.72	33.4	6.58	20,000
3rd Qtr '91	40	0.10	752	<5	38	11.7	18.5	6.9	15,015
4th Qtr '91	67	0.07	473	<5	15	3.07	14.7	N/A	N/A
1st Qtr '92	11	0.05	704	<5	10	1.31	16.8	7.44	16,000
2nd Qtr '92	49	0.04	544	<5	21	1.67	17.8	6.94	16,600
3rd Qtr '92	48	0.02	366	<5	14	2.09	19.1	6.28	10,900
4th Qtr '92	70	0.04	283	6	20	1.50	16.1	6.79	13,000
1st Qtr '93	69	0.07	418	<5	10	4.25	5.8	7.57	14,800
2nd Qtr '93	55	0.03	0.30	<5	9	0.85	5.4	7.33	15,900
3rd Qtr '93	52	0.05	280	<5	56	3.02	8.2	7.05	13,600
4th Qtr '93	45	0.02	295	<5	27	2.32	8.2	6.66	15,800
1st Qtr '94	42	0.02	322	<5	265	55.0	14.9	7.40	12,800
2nd Qtr '94	44	0.05	271	<5	8	0.96	8.3	6.93	11,500
3rd Qtr '94	44	<0.02	290	<5	<4	0.33	5.8	6.74	12,900
4th Qtr '94	42	<0.02	190	<5	12	0.53	22.8	6.79	12,100
1st Qtr '95	44	0.02	240	<5	27	6.79	18.1	7.30	12,100
2nd Qtr '95	42	<0.02	340	<5	56	24.6	15.4	7.27	12,700
3rd Qtr '95	45	0.07	220	<5	49	0.41	8.3	7.41	13,200
4th Qtr '95	40	0.02	280	<5	13	0.40	8.7	6.94	11,800
1st Qtr '96	38	<0.02	250	<5	20	1.16	10.1	7.00	10,900
2nd Qtr '96	40	<0.02	220	<5	8	1.41	16.9	7.29	12,000
3rd Qtr '96	36	0.05	210	22	10	2.56	9.9	6.96	10,000
4th Qtr '96	37	0.04	290	<5	48	6.78	11	6.65	10,100
1st Qtr '97	37	0.04	210	<5	40	8.64	9.8	7.22	11,200
2nd Qtr '97	45	<0.02	410	<5	20	4.7	12.5	6.44	11,600
3rd Qtr '97	37	<0.02	320	<5	12	1.38	9.0	6.56	9,850
4th Qtr '97									

1.C. DACWPF Reconstructed Cell Sump Leachate Analytical Data -
Volatile Organic Compounds

	Benzene (ug/L)	Carbon tetrachloride (ug/L)	Chlorobenzene (ug/L)	Chloroform (ug/L)	1,2 Dichloro-ethane (ug/L)	1,1 Dichloro-ethene (ug/L)	Methyl ethyl ketone (ug/L)	Tetrachloro-ethene (ug/L)	Trichloro-ethene (ug/L)	Vinyl chloride (ug/L)
1st Qtr '91	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
2nd Qtr '91	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
3rd Qtr '91	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
4th Qtr '91	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
1st Qtr '92	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
2nd Qtr '92	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
3rd Qtr '92	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
4th Qtr '92	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
1st Qtr '93	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
2nd Qtr '93	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
3rd Qtr '93	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
4th Qtr '93	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
1st Qtr '94	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
2nd Qtr '94	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
3rd Qtr '94	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
4th Qtr '94	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
1st Qtr '95	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
2nd Qtr '95	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
3rd Qtr '95	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
4th Qtr '95	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
1st Qtr '96	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
2nd Qtr '96	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
3rd Qtr '96	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
4th Qtr '96	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
1st Qtr '97	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
2nd Qtr '97	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
3rd Qtr '97	<10	<50	<50	<50	<50	<50	<1,000	<50	<50	<100
4th Qtr '97										

1.D. DACWPF Reconstructed Cell Leachate Analytical Data - Summary of Semi-Volatile Organic Compounds

	o-Cresol (ug/L)	m & p-Cresol (ug/L)	1,4-Dichloro-benzene (ug/L)	2,4-Dinitro-toluene (ug/L)	Hexachloro-benzene (ug/L)	Hexachloro-butadiene (ug/L)	Hexachloro-ethane (ug/L)	Nitro-benzene (ug/L)	Pentachloro-phenol (ug/L)	Pyridine (ug/L)	2,4,5-Tri-chlorophenol (ug/L)	2,4,6-Tri-chlorophenol (ug/L)
1st Qtr '91	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
2nd Qtr '91	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
3rd Qtr '91	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
4th Qtr '91	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
1st Qtr '92	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
2nd Qtr '92	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
3rd Qtr '92	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
4th Qtr '92	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
1st Qtr '93	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
2nd Qtr '93	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
3rd Qtr '93	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
4th Qtr '93	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
1st Qtr '94	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
2nd Qtr '94	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
3rd Qtr '94	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
4th Qtr '94	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
1st Qtr '95	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
2nd Qtr '95	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
3rd Qtr '95	<100	<100	<100	<100	<100	<100	<100	<100	<500	<100	<100	<100
4th Qtr '95	<100	<100	<100	<100	<100	<100	<100	<100	<500		<100	<100
1st Qtr '96	<10	<10	<10	<10	<10	<10	<10	<10	<50		<10	<10
2nd Qtr '96	<100	<100	<100	<100	<100	<100	<100	<100	<500		<100	<100
3rd Qtr '96	<10	<10	<10	<10	<10	<10	<10	<10	<50		<10	<10
4th Qtr '96	<100	<100	<100	<100	<100	<100	<100	<100	<500		<100	<100
1st Qtr '97	<100	<100	<100	<100	<100	<100	<100	<100	<500		<100	<100
2nd Qtr '97	<100	<100	<100	<100	<100	<100	<100	<100	<500		<100	<100
3rd Qtr '97	<100	<100	<100	<100	<100	<100	<100	<100	<500		<100	<100
4th Qtr '97												

I.E. DACWPF Reconstructed Cell Leachate Analytical Data -
Summary of Pesticide and Herbicide Compounds

	Chlordane (ug/L)	Endrin (ug/L)	Heptachlor (ug/L)	Heptachlor epoxide (ug/L)	gamma-BHC (ug/L)	Methoxychlor (ug/L)	Toxaphene (ug/L)	2,4,-D (ug/L)	2,4,5-TP (ug/L)
1st Qtr '91	<14	<6.0	<3.0	<83	<4.0	<180	<240	<120	<17
2nd Qtr '91	<14	<6.0	<3.0	<83	<4.0	<180	<240	<120	<17
3rd Qtr '91	<14	<6.0	<3.0	<83	<4.0	<180	<240	<120	<17
4th Qtr '91	<14	<6.0	<3.0	<3.0	<4.0	<180	<240	<120	<17
1st Qtr '92	<14	<6.0	<3.0	<3.0	<4.0	<180	<240	<120	<17
2nd Qtr '92	<14	<6.0	<3.0	<3.0	<4.0	<180	<240	<120	<17
3rd Qtr '92	<14	<6.0	<3.0	<3.0	<4.0	<180	<240	<120	<17
4th Qtr '92	<14	<6.0	<3.0	<3.0	<4.0	<180	<240	<120	<17
1st Qtr '93	<1.4	<0.6	<0.3	<0.3	<0.4	<18	<24	<12	<1.7
2nd Qtr '93	<1.4	<0.6	<0.3	<0.3	<0.4	<18	<24	<12	<1.7
3rd Qtr '93	<1.4	<0.6	<0.3	<0.3	<0.4	<18	<24	<12	<1.7
4th Qtr '93	<1.4	<0.6	<0.3	<0.3	<0.4	<18	<24	<0.005	<0.001
1st Qtr '94	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<5	<1
2nd Qtr '94	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<5	<1
3rd Qtr '94	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<42	<6
4th Qtr '94	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<500	<100
1st Qtr '95	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<500	<100
2nd Qtr '95	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<12	<1.7
3rd Qtr '95	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<12	<1.7
4th Qtr '95	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<12	<1.7
1st Qtr '96	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<12	<1.7
2nd Qtr '96	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<12	<1.7
3rd Qtr '96	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<12	<1.7
4th Qtr '96	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<12	<1.7
1st Qtr '97	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<12	<1.7
2nd Qtr '97	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<12	<1.7
3rd Qtr '97	<1.4	<0.6	<0.3	<8.3	<0.4	<18	<24	<12	<1.7
4th Qtr '97									

APPENDIX 2

TOXICITY INFORMATION FOR MAMMALS AND BIRDS

USED TO DERIVE BENCHMARK VALUES

2.A. Toxicity Information for Mammals and Birds Used to Derive Benchmark Values.

Analyte	TBV-Low (mg/kg bw/d)	TBV-High (mg/kg bw/d)	Species	Study Endpoint UF	Study Duration UF	NOAEL (mg/kg bw/d)	LOAEL (mg/kg bw/d)	Study Description	Reference	Comment
Inorganics:										
Arsenic	14.0	42.0	Mallard	1	1	14	42	NOAEL @ 100 ppm in diet for behavior (LOAEL was 300 ppm for behavior and growth). Converted with 0.14 kg diet/kg bw from Camardese et al., 1990.	Camardese et al., 1990; Whitworth et al., 1991	Only avian value.
Arsenic	0.8	22.5	Rat	1	5	3.8	22.5	NOAEL (LOAEL was 22.5 mg/kg bw/day for growth, liver lesions)	Schroeder et al., 1968	Clear endpoint relating to effects on assessment endpoints.
Barium	19.4	194.0	Chicken	1	5	97	194	NOAEL is 1000 ppm diet. Slight growth depression at 2,000-4,000 ppm. Converted with 0.097 kg/kg bw/d from Wiseman (1987).	Johnson et al., 1960	Only avian value.
Barium	7.1	NA	Rat	1	5	35.6	NA	NEL for overt toxicity and survival. Caused hypertension. Estimate from 100 ppm in drinking water and 15 ml/45 g bw/d ingestion rate from same study.	Perry et al., 1989	Only value.
Cadmium	0.1	2.0	Mallard	3	5	NA	2.0	NOAEL for adults; LOAEL for kidney lesions in ducklings. Lesions uncertain for population effects w/o link to survival or repro. Measured 14.6 ppm in diet. Used 42.8 g /798.5 g bw, or 0.054.	White and Finley, 1978	Only avian value.
Cadmium	0.5	NA	Rat	1	5	2.5	NA	NOAEL for behavior, condition, body weight, food consumption (30 ppm)	Groten et al., 1991	Clear endpoint; primary reference.
Chromium (III)	1.3	2.6	Tern	1	1	1.28	NA	NOEL for wild populations. Concentration in major prey items 7.6 ppm converted by author. No effect on reproduction or population success.	CEPA, 1994b	Use this study as it relates directly to assessment endpoint; test species related to receptor species.
Chromium (III)	6.7	NA	Cat	3	1	20	NA	NEL (toxicity endpoint unknown) for 80 day exposure to 50-1000 mg/cat/d; convert with assumed body weight of 2.5 kg.	NAS, 1974a	Use this study as it is long-term; dietary exposure.
Cyanide	0.03	3.0	Mouse	10	10	NA	3	LD50	Jorgensen et al., 1991	
Lead	14.5	43.5	Kestrel	1	1	14.5	NA	NOAEL (for survival, growth) from diet of 50 ppm (25 mg/kg bw/d) converted with 0.29 kg diet/kg bw (kestrel)(EPA, 1993b). A NOAEL of 14.5 mg/kg for survival, histopathology and reproduction also reported.	Franson et al., 1983; Pattee, 1984; Hoffman et al., 1985a,b	Study concerns assessment endpoint and has test species closely related to site receptor species.
Lead (acetate)	4.0	170.0	Rat	3	1	11.985	170	Females on 2000 ppm had higher mortality than controls; males on 500 and 2000, but not 1000 ppm diet had higher mortality. Controls high mortality over 2 year study. Uses 141 ppm as NOAEL, 2000 as LOAEL. Use 0.085 g/g/d, Groton et al., 1991 to convert.	Azar et al., 1973	Study concerns assessment endpoint and has test species closely related to site receptor species. Long term study.

2.A. Toxicity Information for Mammals and Birds Used to Derive Benchmark Values.

Analyte	TBV-Low (mg/kg bw/d)	TBV-High (mg/kg bw/d)	Species	Study Endpoint UF	Study Duration UF	NOAEL (mg/kg bw/d)	LOAEL (mg/kg bw/d)	Study Description	Reference	Comment
Mercury	2.5	12.5	Chicken	1	1	2.5	12.5	NOAEL for growth; 12.5 the LOAEL (convert with 0.097 kg diet/kg bw/day (Wiseman, 1987)). 12.5 mg/kg bw/d affects quail reproduction. 1.1 NEL for starling.	Thaxton et al., 1975; Thaxton et al., 1973; Nicholson and Osborn, 1984.	Only inorganic avian data.
Mercury	0.8	3.9	Mouse	5	1	NA	3.9	Increased morbidity. Converted from 15 ppm in diet with 0.085 g/g/d, Groton et al., 1991.	Mitsumori et al., 1981	Use this study as mice may be more sensitive than rats based on Fitzhugh et al., 1950 study.
Nickel	29.1	87.3	Chicken	3	1	NA	87.3	900 LEL for growth inhibition (estimated from 900 ppm diet and 0.097 kg/kg bw/d from Wiseman, 1987). 1,000 ppm a NEL in other studies.	Venugopal and Luckey, 1978.	Only avian value.
Nickel	52.7	158.0	Rat	3	1	NA	158	TDlo for multigeneration study for effects on embryo or fetus.	RTECs, 1997	Long term.
Selenium	0.660	1.3	Chicken	1	1	0.66	NA	NOAEL for egg production and egg weight, although slight decrease in hatchability.	Ort and Latshaw, 1978	Appropriate toxicity endpoints relative to assessment endpoint. Must remain above required nutrient level.
Selenium	0.038	0.6	Mouse	3	5	NA	0.57	LOAEL for reproductive effects	Opresko et al., 1993	Appropriate toxicity endpoints relative to assessment endpoint. Must remain above required nutrient level.
Silver	29.1	87.3	Turkey	3	1	NA	87.3	LEL for cardiac effects and 28.6% mortality for 18 week study with 900 ppm. Convert with 0.097 kg/kg bw/d from Wiseman, 1987.	Friberg et al., 1979	Only avian value.
Silver	65.0	130.0	Rat	1	1	65	NA	NOAEL for appearance, behavior, fluid consumption, mortality for 12 week study.	Walker, 1971	Both mammalian studies have consistent results.
Thallium	0.2	23.7	Ring-necked pheasant	10	10	NA	23.7	LD50	Hudson et al., 1984	Only avian value.
Thallium	0.1	3.0	Rat	3	10	NA	3	Rats gavaged on gestational days 6-15 had slight increase in postimplantation fetal loss.	Roll and Matthiaschk, 1981	Best study. Reproduction a more sensitive endpoint than overt mortality.
Organics:										
Benzene	130.0	6500.0	Mouse	5	10	NA	6500	TDLo when given at 8-12 days of pregnancy. Effects on newborn growth statistics.	RTECS, 1997 (Teratogen Carcinog. Mutagen. 6:361. 1986)	

2.A. Toxicity Information for Mammals and Birds Used to Derive Benchmark Values.

Analyte	TBV-Low (mg/kg bw/d)	TBV-High (mg/kg bw/d)	Species	Study Endpoint UF	Study Duration UF	NOAEL (mg/kg bw/d)	LOAEL (mg/kg bw/d)	Study Description	Reference	Comment
1,1 Dichloroethene	9.0	9.0	Rat	1	1	NA	9	Caused hepatic lesions. No population level effects noted in this chronic oral study, therefore use LOAEL as NOAEL.	IRIS, 1997	Only data in literature reviewed. This is an inappropriate endpoint for ecological health.
1,2 Dichloroethane	4.7	95.0	Rat	10	1	47	95	All high dose animals died by 23 weeks.	IRIS, 1997	
1.4 Dichlorobenzene	5.0	50.0	Mouse, rat	1	5	25	NA	NOEL, subchronic oral study, endpoints of body weight, survival, histopathology, hematology, organ weight range from 25-125 mg/kg bw/d.	CEPA, 1993a	Note: data are for 1,2 DCB since oral data for 1,4 DCB unavailable
2,4 D	1.0	5.0	Rat	1	1	1	5	90 day oral bioassay. Produced hematologic, hepatic and renal toxicity.	IRIS, 1997	Use this since it is a long-term study.
2,4 Dintirotoluene	0.2	1.5	Dog	1	1	0.2	1.5	Dog feeding study; 2 years. Endpoints were neurotoxicity, Heinz bodies, and biliary tract hyperplasia.	IRIS, 1997	
2,4,5 TP	0.8	2.5	Dog	1	1	0.75	2.5	Oral bioassy with histopathological changes in liver as the endpoints.	IRIS, 1997	Not appropriate endpoint as no clear population-level effects; NOAEL likely overly conservative.
2,4,5 Trichlorophenol	100.0	300.0	Rat	1	1	100	300	Oral study with liver and kidney pathology as the endpoints. Study performed for 98 days.	IRIS, 1997	Not appropriate endpoint as no clear population-level effects; NOAEL likely overly conservative.
2,4,6 Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Carbon tetrachloride	0.7	7.1	Rat	1	1	0.71	7.1	Produced liver lesions. No population level effects noted in this 12-week study. Gavage.	IRIS, 1997	Not appropriate endpoint as no clear population-level effects; NOAEL likely overly conservative.
Chlordane	0.1	2.1	Redwinged blackbird	3	5	2.13	NA	NOAEL for mortality	Opresko et al., 1993	Only value.
Chlorobenzene	19.0	54.5	Dog	1	1	19	54.5	Oral exposure by capsule dosing; histopathology of liver was endpoint. 13 week study.	IRIS, 1997	Not appropriate endpoint as no clear population-level effects; NOAEL likely overly conservative.
Chloroform	0.4	36.0	Mouse	10	10	NA	36	Oral LD50.	RTECS, 1997 (Arch. Toxicol. Suppl. 2:371. 1979)	Most conservative value.
Endrin	0.032	0.19	Mallard	1	1	0.0315	0.189	NEL for reproductive effects in a 12 week study. Dietary level 0.5 ppm. 3 ppm decreased embryo survival, and decreased male body weight by 4.5%. Convert with 0.063 g/g bw/d from EPA (1993).	Roylance et al., 1985	Long term study. Relates to assessment endpoints.

2.A. Toxicity Information for Mammals and Birds Used to Derive Benchmark Values.

Analyte	TBV-Low (mg/kg bw/d)	TBV-High (mg/kg bw/d)	Species	Study Endpoint UF	Study Duration UF	NOAEL (mg/kg bw/d)	LOAEL (mg/kg bw/d)	Study Description	Reference	Comment
Endrin	0.03	0.1	Dog	1	1	0.025	0.05	Chronic oral study. Histological liver lesions, occasional convulsions.	IRIS, 1997	
gamma BHC	0.3	NA	Chicken	3	1	0.97	NA	NEL for mortality in 8 week study where chickens given 10 ppm in diet. Converted with 0.097 kg diet/kg bw/d from Wiseman (1987).	Ritchey et al., 1972	Long term study.
gamma BHC	0.3	1.6	Rat	1	1	0.33	1.55	Oral bioassay. Endpoints were liver and kidney toxicity. Duration of 12 weeks.	IRIS, 1997	
Heptachlor	0.3	NA	Chicken	3	1	0.97	NA	NEL for mortality in 8 week study where chickens given 10 ppm in diet. Converted with 0.097 kg diet/kg bw/d from Wiseman (1987).	Ritchey et al., 1972	Long term study.
Heptachlor	0.2	0.3	Rat	1	1	0.15	0.25	Chronic feeding study. Endpoints were liver weight increases.	IRIS, 1997	
Heptachlor epoxide	0.010	0.01	Dog	1	1	NA	0.01	Chronic dog feeding study. Endpoint was increased liver to body weight ratio. This has no direct link with population effects, so use LOAEL as NOAEL without additional UF.	IRIS, 1997	Not appropriate endpoint as no clear population-level effects; NOAEL likely overly conservative.
Hexachlorobenzene	0.1	0.3	Rat	1	1	0.08	0.29	Chronic feeding study that included reproductive-toxicity in F1 generation, liver effects.	IRIS, 1997	
Hexachlorobutadiene	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Hexachloroethane	1.0	15.0	Rat	1	1	1	15	Dietary study using atrophy and degeneration of the renal tubules as the endpoint. 16 week duration.	IRIS, 1997	
m&p Cresol	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Methyl ethyl ketone	50.0	100.0	Rat	1	1	50	NA	NOAEL for Methyl isobutyl ketone for body weight, food consumption, organ weight, histopathology, morbidity, clinical chemistry, hematology for 13 week study.	WHO, 1990	Only value
Methoxychlor	28.6	2000.0	Mallard, sharp tailed grouse, California quail	7	10	NA	2000	LD50 exceeded 2,000 mg/kg bw for all species.	Hudson et al., 1984	Only value.
Methoxychlor	5.0	35.5	Rabbit	1	1	5.01	35.5	Reproductive study with excessive loss of litters as endpoint.	IRIS, 1997	
Nitrobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	
o-Cresol	NA	NA	NA	NA	NA	NA	NA	NA	NA	

2.A. Toxicity Information for Mammals and Birds Used to Derive Benchmark Values.

Analyte	TBV-Low (mg/kg bw/d)	TBV-High (mg/kg bw/d)	Species	Study Endpoint UF	Study Duration UF	NOAEL (mg/kg bw/d)	LOAEL (mg/kg bw/d)	Study Description	Reference	Comment
Pentachlorophenol	3.0	30.0	Rat	1	1	3	30	Chronic oral study with liver and kidney pathology as the endpoint; also body weight gain. Use the LOAEL for body weight gain as a population level effect.	IRIS, 1997	Pathology not appropriate endpoint as no clear population-level effects.
Pyridine	1.0	10.0	Rat	1	1	1	10	Oral gavage study with increased liver weight as the endpoint.	IRIS, 1997	Not appropriate endpoint as no clear population-level effects; NOAEL likely overly conservative.
Tetrachloroethene	14.0	71.0	Rat, Mouse	1	1	14	71	Oral gavage study with hepatotoxicity and body weight gain as endpoints. 6 week study.	IRIS, 1997	Appropriate toxicity endpoint relative to assessment endpoint. Avoid extrapolating from inhalation when possible.
Toxaphene	0.2	19.9	Sharp-tailed grouse	10	10	NA	19.9	LD50	Hudson et al., 1984	Only value.
Trichloroethene	33.3	100.0	Mouse	3	1	NA	100	Increased liver weight in 6 week oral study.	CEPA, 1993b	Chronic oral study.
Vinyl chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	

EXHIBIT C

TECHNICAL MEMORANDUM

UPDATED RISK BASED SCREENING LEVELS FOR RECONSTRUCTED CELL LEACHATE AT THE DENVER ARAPAHOE CHEMICAL WASTE PROCESSING FACILITY ARAPAHOE COUNTY, COLORADO

June 22, 2009

FINAL

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1.0 INTRODUCTION

In 1998, Waste Management of Colorado, Inc. (WMCI) filed a Conditional Delisting Petition for Reconstructed Cell Leachate at the Denver Arapahoe Chemical Waste Processing Facility, Arapahoe County, Colorado. A risk assessment based on 1998 analytical data was used to predict potential human health and environmental risks due to use of the leachate for dust suppression at a lined solid waste disposal facility. WMCI continues to utilize this leachate for dust suppression.

The leachate is applied to temporary cover only within an inactive area of the landfill, and haulers are not allowed onto the cover for at least 30 days following leachate application. Ultimately, additional layers of trash and cover are added which covers the soils to which leachate was applied.

There are no current residents at the disposal facility; therefore, only WMCI workers that are actively engaged in applying the leachate and ecological receptors potentially contact the leachate or the soils to which leachate is applied. The 1998 Risk Assessment, which focused on non-volatile constituents as volatiles had never been detected, indicated that personal protective equipment (PPE) should be worn by workers to avoid dermal contact with the leachate; therefore, workers wear protective gloves and boots (standard level D).

The 1998 Risk Assessment was used to establish a leachate application rate of <3600 gallons per acre, which is the permitted amount. However, typically less than 3600 gallons (13,600 L) is applied at any one time, but the application rate of <3600 gallons per acre is maintained. The leachate is sprayed from a truck with a 3 inch (7.62 cm) nozzle, from a height of approximately 5.5 feet (1.68 m) above ground surface. It takes approximately 20 minutes to apply the leachate. The worker remains in the truck during this time (height approximately 6-7 feet (2 m) above ground surface). The application is contained within the footprint of a lined cell so that percolation to groundwater is not a potential release. This also eliminates the potential for release to surface water, and any potential risks to benthic or aquatic life.

Concentrations of analytes in leachate may vary over time from the concentrations used to predict risk in the 1998 Risk Assessment which provided the basis for the conditional delisting of the reconstructed cell leachate for use in dust suppression. As a result, risk-based screening levels (RBSLs) were developed in 2008 (Terra Technologies, 2008) based on the parameters used in the 1998 Risk Assessment to provide WMCI with a tool by which they can determine if they are meeting the requirements of the Delisting Petition over time. The RBSLs were calculated for baseline conditions; i.e., in the event that PPE was not used. They are therefore conservative for site conditions where use of PPE is mandatory. Additionally, the 2008 RBSLs are based on the Site-Specific Industrial Worker as defined in the 1998 Risk Assessment which utilized conservative exposure parameters for frequency, duration, and exposure time. The WMCI worker sprays leachate no more than 4 times (more likely 2 times) per year for a maximum of approximately 20 minutes, for up to a worker's typical career span of 30 years. Workers do not get out of the truck to contact wetted soils or leachate except in the rare event of equipment malfunction. The 2008 RBSLs were not developed for residential use since, under the conditional delisting, the leachate can only be applied at a solid waste disposal facility. It is extremely unlikely that residential use is a potential future use at that disposal facility and, even if it was, the leachate can not be applied to the final cover of the facility.

The purpose of this analysis was to compare the 1998 to current toxicity values, and also to critically evaluate exposure assessment assumptions and update the original exposure assumption estimates with site-specific data to the greatest extent possible. Updated RBSLs are calculated based on updated values and modeling assumptions, and compared to those based on the values from the 1998 Risk Assessment that were used in the 2008 RBSL Report.

2.0 METHODS

RBSLs are soil and leachate concentrations that correspond to a preset target cancer risk or noncancer risk level for a given exposure scenario. The RBSLs are designed to be compared directly to analytical data. Figure 1 shows a conceptual model for the leachate application.

Exposure pathways that were determined to be potentially complete in the absence of PPE are shown in Table 1. This includes incidental ingestion, dermal contact, and inhalation of dusts and vapors. The soil contact equations presume that leachate is sprayed onto the soils, and that WMCI workers then contact the soils. It is conservative in that there are no attenuation factors, and the equation assumes that any chemical in the leachate transfers directly to the soil. In addition, direct ingestion and contact with leachate and inhalation of volatiles from leachate are considered.

The equations used to derive these 2009 RBSLs for soil were obtained from EPA Region 3 (EPA, 2008) and are considered the “Regional Preliminary Remedial Goals (Regional PRGs)”, meaning that they represent current practice by multiple EPA regions. They are derived from forward-type risk equations (EPA, 1989), which predict a risk based on a concentration in some exposure medium. However, the RBSL equations are “backward” in that risk is fixed at a target level, and the corresponding concentration in the exposure medium (soil or leachate) is then solved for. This results in a media concentration associated with a preset or “target” level of risk. In order to evaluate the potential contribution of each pathway, the equations are solved for each exposure pathway separately prior to combining them for an overall RBSL.

Section 2.1 presents the equations for the soil exposure pathways as they were applied in the 2008 RBSL Report and the 1998 Risk Assessment (collectively "2008/1998 Analysis"), and compares them to the current equations for the 2009 RBSLs. Exposure parameters and toxicity values applicable to the soil exposure pathways are also discussed. Section 2.2 presents the equations in the 2008/1998 Analysis compared to current equations for the leachate exposure pathways. Exposure parameters and toxicity values from the 2008/1998 Analysis are compared to those identified as site-specific at this time. Section 2.3 demonstrates how the exposure to the separate media can be combined to produce a leachate concentration that can be safely applied accounting for all potential exposure pathways.

2.1 Soil Exposure Pathways

2.1.1 Equations

2.1.1.1 2008/1998 Analysis

Human health risk equations are specific to cancer and noncancer toxicological endpoints, and are described below. The equation used in the 2008/1998 Analysis followed EPA guidance practiced in 1998 and combined the soil ingestion, soil dermal contact, and particulate inhalation pathways for evaluation of risk as follows (EPA, 2004a):

Equation 1 – 2008/1998 Analysis Combined Soil Exposure, Cancer Risk

$$Csoil = \frac{TR \times BWa \times ATc}{EF \times ED \times \left[\left(\frac{IRS \times CSFo}{CF1}\right) + \left(\frac{SA \times AF \times ABS \times CSFo}{CF1}\right) + \left(\frac{ET \times IRA \times CSFi}{PEF}\right)\right]}$$

The receptor-specific parameters used in the 2008/1998 Analysis are defined in Table 2. Current default EPA values are also shown in this table for comparison, as well as values recommended for use in the current analysis based on site-specific information. While the 2009 exposure parameters differ from those used in the 2008/1998 Analysis, they reflect actual practice at the site. Therefore, any RBSLs derived using these parameters reflect a conservative but realistic concentration to which workers can be exposed without risk under baseline (i.e., no PPE) conditions.

Table 3 presents the toxicity values from the 2008/1998 Analysis and those currently used by EPA. Toxicity values change over time as new data are introduced and older, obsolete values withdrawn.

The inhalation cancer slope factor (CSFi) used in Equation 1 above is a derived value. The CSFi used in the inhalation component of Equation 1 was derived from the Inhalation Unit Risk (IUR) (Table 3) as shown in Equation 2 below. The parameters are defined in Table 2. Use of a CSFi was considered standard practice at the time of the 1998 Risk Assessment (EPA, 2004a).

Equation 2 – 2008/1998 Analysis Inhalation Cancer Slope Factor

$$CSFi\ (mg/kg-d)^{-1} = IUR\ m^3/ug \times 70\ kg \times 1\ d/20\ m^3 \times 1000\ ug/mg$$

The equation used in the 2008/1998 Analysis to calculate the noncancer RBSL for soils differs from the cancer equation since it utilizes a target hazard quotient (THQ) instead of a target cancer risk (TR), and it relies on the RfD instead of the oral cancer slope factor (CSFo) as the toxicity endpoint. The noncancer combined equation is as follows:

Equation 3 – 2008/1998 Analysis Combined Soil Exposure, Cancer Risk

$$Csoil = \frac{THQ \times BWa \times ATnc}{EF \times ED \times \left[\left(\frac{IRS \times 1/RfD}{CF1}\right) + \left(\frac{SA \times AF \times ABS \times 1/RfD}{CF1}\right) + \left(\frac{ET \times IRA \times 1/RfDi}{PEF}\right)\right]}$$

The inhalation reference dose (RfDi) was derived from the oral reference dose (RfD) as follows (EPA, 2004):

Equation 4– 2008/1998 Analysis Inhalation Noncancer Reference Dose

$$RfDi\ (mg/kg-d) = RfC\ mg/m^3 \times 20\ m^3/d \times 1/70\ kg$$

2.1.1.2 2009 RBSLs

The approach for estimating the 2009 soil RBSL involves solving individual equations to obtain pathway-specific screening levels (SLs) in terms of milligram contaminant per kilogram soil (mg/kg) for the ingestion (ing), dermal (derm), and inhalation (inh) exposure pathways. The inverse of the individual pathways is then summed to obtain a single soil concentration representative of all pathways. This allows identification of the most important exposure pathways and aids transparency. Thus, to estimate cancer risk for soil exposure, the following equations are used (EPA, 2008):

Equation 5 – 2009 Cancer Risk, Soil Ingestion

$$SLing = \frac{TR \times BWa \times ATc}{EF \times ED \times CSFo \times IRS \times 10^{-6}\ kg/mg}$$

Equation 6 – 2009 Cancer Risk, Soil Dermal Contact

$$SLderm = \frac{TR \times BWa \times ATc}{EF \times ED \times \frac{CSFo}{GIABS} \times SA \times AF \times ABS \times 10^{-6}\ kg/mg}$$

Equation 7 – 2009 Cancer Risk, Soil Inhalation

$$SLinh = \frac{TR \times ATc}{EF \times ED \times ET \times \frac{1\,day}{24\,h} \times IUR \times 1000\,ug/mg \times \left[\frac{1}{VFs} + \frac{1}{PEF}\right]}$$

The current approach for estimating a noncancer RBSL for soil is (EPA, 2008):

Equation 8 – 2009 Noncancer Risk, Soil Ingestion

$$SLing = \frac{THQ \times BWa \times ATnc}{EF \times ED \times \frac{1}{RfDo} \times IRS \times 10^{-6}\ kg/mg}$$

Equation 9 – 2009 Noncancer Risk, Soil Dermal Contact

$$SLderm = \frac{THQ \times BWa \times ATnc}{EF \times ED \times \frac{1}{RfDo \times GIABS} \times SA \times AF \times ABS \times 10^{-6}\ kg/mg}$$

Equation 10 – 2009 Noncancer Risk, Soil Inhalation

$$SLinh = \frac{THQ \times ATnc}{EF \times ED \times ET \times \frac{1\,day}{24\,h} \times \frac{1}{RfC} \times \left[\frac{1}{VFs} + \frac{1}{PEF}\right]}$$

The amount of chemical that enters the air as fugitive dust is estimated with the particulate emission factor (PEF). The amount of chemical entering air in a vapor state due to volatilization from soil is estimated with the volatilization factor for soil (VFs). The PEF was obtained from EPA (2008). The VF was calculated with equations and parameters from EPA (2008), which in turn cites the Soil Screening Guidance (EPA, 1996):

Equation 11 – 2009 Volatilization Factor for Soils

$$VFs = \frac{Q/C \times (3.14 \times D_A \times T)^{1/2} \times 10^{-4} m^2/cm^2}{2 \times \rho b \times D_A}$$

Where:

VFs = Volatilization factor for soils (m^3/kg)
T = Exposure interval (s) (Default value of 9.50E+08 used)
ρb = Dry bulk soil density (g/cm^3) (Default value of 1.5 used)
D_A = Apparent diffusivity (cm^2/s)
Q/C = Inverse of mean concentration at center of square source (g/m^2-s per kg/m^3)

The default parameters for Equation 11 are not readily apparent from EPA (2008), and thus the parameters in the 1996 Soil Screening Guidance were used as the defaults. EPA (2008) provides Q/C values by location and for different site sizes. A value of 1 acre was used for the site to estimate Q/C because this is the size of the typical application area for the leachate; other Q/C values are shown below as a comparison:

Q/C for Denver, Colorado							
Site Size (ac)	**0.5**	**1**	**2**	**5**	**10**	**30**	**Default**
Q/C	75.59	66.27	58.68	50.64	45.52	38.87	68.81

The apparent diffusivity (D_A) is chemical specific and was calculated from parameters and equations provided by EPA (2008) (Table 4). D_A, used to estimate VF, is calculated with Equation 12 (EPA, 1996) below.

Equation 12 – 2009 Apparent Diffusivity

$$D_A = \frac{\left(\theta_a^{10/3} \times D_{ia} \times H' + \theta_w^{10/3} \times D_{iw}\right)/n^2}{\rho_b \times K_d + \theta_w + \theta_a \times H'}$$

Where:

ρ_b = Dry bulk soil density (g/cm^3) (Default value of 1.5 used)
θ_a = Air filled soil porosity (L/L) (Default value of 0.28)
n = Total soil porosity (L/L) (Default value of 0.43)
θ_w = Water filled soil porosity (L/L) (Default value of 0.15)
K_d = Soil-water partition coefficient (Koc*foc)
K_{oc} = Soil-water partition coefficient normalized for organic carbon (cm^3/g)

f_{oc} = Fraction organic carbon (g/g) (Default value of 0.006)
D_{ia} = Diffusivity in air (cm^2/s)
D_{iw} = Diffusivity in water (cm^2/s)
H' = Henry's law constant (dimensionless form)

Default values for various soil properties from EPA (1996) are incorporated into the calculation of D_A. The other values are chemical specific and are shown in Table 4.

The parameters in the soil ingestion component of the 2009 equations are the same as those used in the 2008/1998 Analysis. However, the dermal contact pathway of the 2009 RBSL contains a new chemical-specific parameter that accounts for the fraction of gastrointestinal absorption (GIABS). The inhalation component of the 2009 RBSL now contains a parameter to estimate volatilization from soils (VFs), a correction factor for the fraction of the work day for which exposure occurs (exposure time (ET) of 8 hours /day * 1 day/24 hours), and the toxicity values CSFi or RfCi are not used. Only the inhalation unit risk (IUR) or reference concentration (RfC) are applied to the inhalation component of the overall 2009 RBSL. These changes result in removal of body weight (BW) from the numerator, which also is different from the 2008/1998 version of the equations. In addition, the parameter for inhalation rate was removed from the 2009 RBSL denominator as the equations are now based on air concentration, and not dose.

The total cancer or noncancer soil screening level or soil RBSL for all soil-based pathways combined is calculated from the results of Equations 5, 6, and 7 for cancer; and 8, 9, and 10 for noncancer. For soil, the total RBSL is as follows:

Equation 13 – Total 2009 Soil RBSL as Expressed by Summation of Exposure Pathways

$$RBSL_{soil}(mg/kg) = \frac{1}{\frac{1}{SLing} + \frac{1}{SLderm} + \frac{1}{SLinh}}$$

2.1.2 Parameters

The receptor-specific parameters are presented in Table 2; chemical-specific exposure parameters are presented in Table 4. EPA (2008) uses conservative parameters as the default values in the Regional PRGs. However, many of these are not applicable to the existing known industrial use at the site. The current EPA default exposure frequency (EF) and duration (ED) for workers is 250 days/yr for 25 years. The 2008/1998 Analysis used 60 days/yr for a period of 10 years. This analysis uses site-specific data to develop a conservative estimate of EF of 4 days per year for an ED of 30 years.

The current EPA default particulate emission factor (PEF) is lower than the value used for the site in the 2008/1998 Analysis; an even lower value is obtained for the Denver area based on EPA (2008). Because it is a reciprocal in the denominator, a lower PEF results in a more conservative, lower RBSL. Thus, estimation of particulate inhalation is more conservative in this analysis than previous work.

EPA (2008) recommends less conservative factors for soil ingestion rate (IRS), surface area (SA), and adherence factor (AF) than used in the 2008/1998 Analysis (Table 2). The ABS was set to a fixed value of 0.5 in the 2008/1998 Analysis, and now it varies by chemical. When an ABS is not provided by EPA

(2004b), it is standard practice to not estimate dermal risk for that chemical. Figure 2 shows a comparison of the various parameters grouped according to the exposure pathways they are applied to.

In calculating the 2009 RBSLs, the default target cancer risk (TR) is conservatively set to the low end of the allowable risk range, 10^{-6}, equivalent to a cancer risk of 1 excess cancer per million exposed people. The target hazard quotient (THQ) for predicting the risk of noncancer effects is set to one. These assumptions are similar in the 2008/1998 Analysis. Sometimes other cancer risk levels are considered acceptable, as the target cancer risk range documented in EPA regulations is 10^{-6} to 10^{-4}. The THQ is always set to one.

2.1.3 Toxicity Values

Table 3 presents the current toxicity values compared to values reported in the 2008/1998 Analysis. Several toxicity values have changed over the last decade. The 2008/1998 Analysis toxicity values were obtained from EPA's Integrated Risk Information System (IRIS) and the EPA Health Effects Summary Tables (HEAST). The current values track to IRIS, HEAST, as well as other regulatory sources and were obtained from EPA (2008). IRIS values are still considered the "best" toxicity endpoint, and the others are considered more uncertain and subject to change. Caution should be used if making remedial decisions on any but IRIS toxicity values. The RfDi and CSFi are no longer used. Figure 3 shows a comparison of the current values to those used in the 2008/1998 Analysis.

2.2 Leachate Exposure Pathways

There are three potentially complete exposure pathways associated with leachate exposure by workers. These are direct ingestion, dermal contact, and inhalation of volatiles emanating from the spray as it is applied.

2.2.1 Equations

2.2.1.1 2008/1998 Analysis

The equation that was used to calculate the cancer-based RBSL for leachate (termed the C_L to distinguish it from soil screening levels) for ingestion of, and dermal contact with, leachate in the 2008 RBSL Report was similar to the 1998 soil equations and utilized parameters from Tables 2 and 3. As described in Section 1, these RBSLs are derived for the "baseline" condition in that they assume that there is no PPE and that each of the potential exposure pathways is complete. In the 2008/1998 Analysis, a chemical specific permeability coefficient (PC) was required to estimate dermal uptake from liquids (Table 5):

Equation 14- 2008/1998 Analysis Combined Leachate Exposure, Cancer Risk

$$C_L(mg/L) = \frac{TR \times BWa \times ATc}{ET \times EF \times ED \times \left[\left(CR_h \times CSFo\right) + \left(SAw \times PC \times CFw \times CSFo\right)\right]}$$

The equation used to calculate the noncancer-based RBSL for ingestion of, and dermal contact with, leachate was:

Equation 15- 2008/1998 Analysis Combined Leachate Exposure, Noncancer Risk

$$C_L(mg/L) = \frac{THQ \times BWa \times ATnc}{ET \times EF \times ED \times \left[\left(CR_h \times 1/RfDo\right) + \left(SAw \times PC \times CFw \times 1/RfDo\right)\right]}$$

2.2.1.2 2009 RBSL

The current approach used in this analysis to evaluate the 2009 leachate RBSLs remains consistent with the 2009 soil RBSL equation in that the different pathways are estimated separately, allowing conclusions to be drawn regarding the most important exposure pathways for any given analyte.

The equation used for ingestion of leachate resembles that for tap water; however, incidental ingestion of leachate was presumed to resemble an ingestion rate of water lower than drinking water ingestion or incidental ingestion during swimming and not the higher ingestion rates due to potable use. It was assumed that at most workers would ingest 5 ml (1 teaspoon) of leachate per hour for a 20 minute duration of leachate application. The factor for exposure time (ET) is removed from the 2009 RBSL denominator, and the units on ingestion rate (CR) are given in L/d instead of L/h as in the 2008/1998 Analysis Equations 14 and 15, above. Thus, the current equations are:

Equation 16 – 2009 Cancer Risk, Leachate Ingestion

$$SLing = \frac{TR \times BWa \times ATc}{EF \times ED \times CSFo \times CR_d}$$

Equation 17 – 2009 Noncancer Risk, Leachate Ingestion

$$SLing = \frac{THQ \times BWa \times ATnc}{EF \times ED \times \frac{1}{RfDo} \times CR_d}$$

The current approach used in this analysis for addressing dermal uptake is consistent with RAGS E (EPA, 2004b). Note that evaluating uptake from liquids is still not standard practice in the default PRG equations; the documentation for evaluating this exposure pathway is found in Appendix A of RAGS E (EPA, 2004b). The approach involves estimating a dose absorbed from liquid across the dermal membrane into the body. The dermal absorbed dose (DAD) from liquids is as follows:

Equation 18 – 2009 Equation for Estimating Dermal Absorbed Dose

$$DAD\ \frac{mg}{kg-d} = \frac{C_L \times Kp \times tevent \times SA \times EV \times EF \times ED}{BW \times AT}$$

The parameters are defined in Table 2. Equation 18 is multiplied by the CSFo to obtain cancer risk, or divided by the RfDo to obtain noncancer hazard quotient. Either equation can be rearranged to solve for

the leachate concentration (C_L), which is the basis of the screening level for the WMCI leachate in units of mg/L. Pre-established cancer or noncancer risk levels (TR or THQ) are substituted for the variable risk obtained in forward risk equations. The rearrangement produces equations for the pathway-specific screening levels (SLs) as follows:

Equation 19 – 2009 Cancer Risk, Leachate Dermal Contact

$$SLderm = \frac{TR \times BWa \times ATc}{EF \times ED \times CSFo \times Kp \times tevent \times SAw \times EV \times 0.001\ L/cm3}$$

Equation 20 – 2009 Noncancer Risk, Leachate Dermal Contact

$$SLderm = \frac{THQ \times BWa \times ATnc}{EF \times ED \times \frac{1}{RfDo} \times Kp \times tevent \times SAw \times EV \times 0.001\ L/cm3}$$

2.2.2 Leachate Volatilization Model

Estimating inhalation of volatiles emanating from spray requires application of an air model to predict emissions and the resulting air concentration. Several models were reviewed for applicability, including EPA's IWAIR and WAT9. Neither appeared satisfactory for the purpose of estimating emissions from spray. A review of the available literature indicated other analyses had applied what is known as a "shower model". These are models designed to predict volatile organics (VOCs) in air due to use of contaminated water for showering. There are models ranging from simple estimates based on Henry's Law (H), to more complex models which are based on what is referred to as "two film theory" or "two resistance mass transfer theory" (EPA, 1996; Lewis and Whitman, 1924; Little, 1992; Smith et al., 1980; McKone, 1987; Moya et al., 1999). Essentially, the more complicated models all recognize that transfer of a volatile from a liquid to air is dependent on the resistance to the exchange between the liquid and the gas phases, and the simple models predict air concentrations simply on the basis of partitioning and assumed equilibrium. The simple models are more conservative as there is no "cap" on the concentration that can occur in air.

A screening level model (Sanders, 2002) was applied that predicts air concentrations on the basis of Henry's Law (H), and estimated air and water volumes. This screening model was developed for estimating exposure to VOCs in shower air:

Equation 21 - Leachate Volatilization Model

$$C_{air} = C_L \times \left(\frac{H'V_L}{H'V_{air} + V_L} \right)$$

Where:

C_{air} = estimated air concentration (mg/m^3)
C_L = leachate concentration (mg/m^3)
H' = dimensionless Henry's Law coefficient
V_{air} = volume of air for dispersal (L)
V_L = volume of leachate (L)

Rearranging this model, the air concentration divided by the portion of equation 21 in parenthesis (the leachate volatilization factor or V_{leach}) yields the corresponding liquid concentration. Simple substitution of the appropriate exposure parameters and site specific volume parameters results in a leachate concentration that would not exceed a safe air concentration under the modeling assumptions.

The volume of leachate was set to 3600 gal (13,600 L). It is known that the leachate is rapidly applied to a surface area of 1 acre (43,560 ft^2/ac or 4,050 m^2/ac) from a height of nearly 6 ft (approximately 1.68 m). Vapors could dissipate upward or outward; thus a hypothetical box was assumed to occur between ground and 10 ft above ground (3.05 m) over the 1 acre parcel. The volume of air in the 1 acre parcel, 10 feet high is 12,352 m^3 or 12,352,500 L. Obviously, any wind will increase dispersion beyond this box and thus result in lower air concentrations.

The equations to predict cancer and noncancer risk due to volatilization from liquid to air are:

Equation 22 –Volatilization from Spray, Cancer Risk

$$SLinh = \frac{TR \times ATc}{ET \times EF \times ED \times \frac{1d}{24h} \times IUR \times 1000 \frac{\mu g}{mg} \times 1000 \frac{L}{m3} \times \frac{H'V_L}{H'V_{air} + V_L}}$$

Equation 23 – Volatilization from Spray, Noncancer Risk

$$SLinh = \frac{THQ \times ATc}{ET \times EF \times ED \times \frac{1d}{24h} \times \frac{1}{RfC} \times 1000 \frac{L}{m3} \times \frac{H'V_L}{H'V_{air} + V_L}}$$

The total cancer or noncancer screening level or RBSL for all leachate pathways combined is calculated from the results of Equations 16, 19, and 22 for cancer; and 17, 20, and 23 for noncancer, as follows:

Equation 24 – Leachate RBSL, All Pathways Combined

$$RBSL_{leachate}(mg/L) = \frac{1}{\frac{1}{SLing} + \frac{1}{SLderm} + \frac{1}{SLinh}}$$

2.2.3 Parameters

The receptor-specific parameters are presented in Table 2; chemical-specific exposure parameters are presented in Table 4. The standard surface area for dermal contact is now considered to be 3300 cm^2 as a default and not 4700 cm^2. The permeability coefficients which are used to estimate dermal uptake from water or leachate are now termed Kp and not PC. The underlying assumptions and equations used to calculate these Kp values were changed by EPA (2004b), so many of these differ from the ones used in the 2008/1998 Analysis. The new Kp values (Table 4) were obtained directly from EPA (2004c). The units for surface area (SA) are now cm^2, and not cm^2/day.

2.2.4 Toxicity Values

The toxicity values are the same as those used for the soil exposure pathways (Section 2.1.3).

2.3 Combined Equation for Leachate and Soil Pathways

In order to establish an RBSL protective of all of the soil and leachate pathways, the RBLSs derived for each medium must be combined. In addition, the volume of leachate applied to a given area of soil must be factored in. The equation used to combine the soil and leachate RBSLs can be visualized as follows:

Equation 25 – RBSL Inclusive of All Exposure Pathways

$$RBSL_{all}\ (mg/L) = \frac{1}{\frac{1}{RBSL_{soil}} + \frac{1}{RBSL_{leachate}}}$$

However, the RBSLs for soil and leachate cannot be additively combined as they are in terms of different units. The concentrations in soil are themselves dependent on the leachate concentration (Figure 1). A soil concentration can be linked to the leachate concentration as follows, conservatively assuming there is 100% efficiency in cross-media transfer:

Equation 26 – Relationship of Soil Concentrations to Applied Leachate Concentrations

$$Csoil = CL * VL * \frac{1}{Ms}$$

Where:
Csoil = Soil concentration (mg/kg)
CL = Leachate concentration (mg/L)
VL = Volume of leachate applied (13,626 L/ac)
Ms = Mass of soil per acre (803,116 kg/ac)

Equation 25 can therefore be rewritten as follows to solve for a leachate RBSL (i.e., the allowable leachate concentration) given all the potential exposure pathways. Note that as described in Section 1, these RBSLs assume that there is no PPE and that the exposure pathways are complete. Equation 27 is the equation for the leachate RBSL considering cumulative exposure across all soil and leachate pathways:

Equation 27 – RBSL Inclusive of All Exposure Pathways and Media

$$RBSL_{all}\ (mg/L) = \frac{1}{\frac{1}{\frac{RBSL_{soil} \times Ms}{VL}} + \frac{1}{RBSL_{leachate}}}$$

Where:
$RBSL_{all}$ = the allowable leachate concentration (mg/L) without PPE

3.0 RESULTS

Where toxicity data are lacking (Table 3), no predictions of risk can be made. The current revision fills all gaps in the toxicity database relative to the 1998 Risk Assessment in that every chemical has either a cancer CSFo or a noncancer RfD by which to assess risk. It is not uncommon for a chemical to have an RfD but not a CSFo as not all chemicals are known carcinogens. These toxicity data represent the current scientific knowledge as typically applied to risk assessment. Note that the 2008 RBSL Report did not include an RBSL for the following analytes due to lack of toxicity values in the 1998 Risk Assessment:

- Trichloroethene,
- m-, o- and p- Cresol, and
- Lead

These analytes have been addressed in this report.

3.1 RBSL Concentrations by Medium

Tables 6 and 7 present the soil RBSLs based on a cancer or a noncancer endpoint, respectively. Tables 8 and 9 present the leachate RBSLs predicted for a cancer or a noncancer endpoint. The RBSL values are all based on current toxicity values; the only difference in the RBSLs is due to the underlying exposure parameters in Table 2. The RBSLs are reported as follows:

- EPA Default – these are RBSLs based on exposure parameters for a standard EPA default worker,
- 2008/1998 - the "original" site receptor modeled with exposure parameters from the 1998 Risk Assessment and RBSL equations presented in the 2008 RBSL Report, and
- 2009 –the RBSLs are based on exposure parameters that are based on current site-specific parameters.

The volatilization from spray to air pathway is the most conservative pathway for the VOCs and SVOCs.

3.2 Effect of Exposure Parameters on RBSLs

For soils and leachate, the EPA standard parameters result in the lowest RBSLs. These parameters are overly conservative for this site, as they are based on workers exposed all day (8 hr) throughout a 250 day work year. The application is much less frequent; workers are only exposed at most 4 days per year, and the application is completed within no more than 20 minutes. Thus, actual exposure to onsite workers is much lower than the default values.

Revising the parameters relative to those used in the 2008/1998 Analysis also produces a higher RBSL. For some of the chemicals, the range of the RBSLs produced by standard EPA default parameters, the 2008/1998 values, and the 2009 values is nearly two orders of magnitude due to modifying the exposure assumptions to reflect site-specific conditions. The difference across all chemicals is not consistent because some chemicals are not evaluated for every pathway

3.3 RBSLs for All Exposure Pathways and Media Combined

Table 10 presents the leachate RBSLs for all potential exposure pathways and all media combined. These are conservative estimates, particularly for the VOCs, since loss of chemical to air is not accounted for in estimating the soil concentrations.

3.4 Comparison of RBSLs to Measured Data

Table 11 compares the leachate RBSLs to measured concentrations or reporting limits for samples from the Primary Sump, which is the more contaminated of the sumps. Only the following five analytes have been detected in that sump:

- Tetrachloroethene,
- Trichloroethene,
- Cadmium,
- Nickel, and
- Total Cyanide.

None of the detections exceed the 2009 RBSLs. However, tetrachloroethene, trichloroethene, and total cyanide detections exceed the RBSLs based on EPA default parameters. Tetrachloroethene exceeds the 2008 RBSL as well. Note that these are all volatile, and it is the inhalation of vapors emanating from leachate during spraying pathway that drives the analysis. This is readily apparent by comparing the RBSLs in Tables 6 through 9. The lowest RBSL for any given exposure pathway has the greatest influence on the total RBSL for all exposure pathways.

Numerous reporting limits exceed the minimum RBSL based on EPA default exposure parameters; fewer reporting limits exceed the RBSLs based on the 2008/1998 Analysis; and the reporting limits for only two analytes (pentachlorophenol and hexachlorobenzene) exceed the 2009 RBSL. However, neither of these two chemicals has been detected at its method detection limit of 0.0185 mg/L, which is lower than the 2009 RBSL.

3.5 Lead

Lead risks are evaluated in risk assessments with a pharmacokinetic model (EPA, 1994; EPA, 2003). The allowable lead concentration in soil (taking into consideration the exposure pathways of particulate inhalation, soil ingestion, and soil dermal exposure) is 800 mg/kg for non-residential sites, and the maximum allowable concentration (MCL) of lead in drinking water is 0.015 mg/L.

Lead has not been detected in the leachate at a reporting limit of 0.03 mg/L. At a concentration of 0.03 mg/L, and a leachate application rate of 3,600 gal/ac (13,626 L/ac), the amount of lead applied would be 408 mg/ac. Applying a soil mass of 803,116 kg/ac, this amounts to 0.0005 mg/kg lead due to leachate application, which is far less than the allowable lead soil concentration of 800 mg/kg for non-residential sites. The additional soil concentration due to leachate application (0.0005 mg/kg) is very low and well below the industrial PRG.

A person drinking a typical 2 L of water per day at a concentration equal to the MCL of 0.015 mg/L would ingest a total amount of 0.03 mg/d lead. At the much lower site-specific incidental ingestion rate of leachate (1 teaspoon), only a small fraction of this allowable total amount would be ingested (0.00002475 mg/d). A leachate concentration of over 18 mg/L would be required to exceed the allowable daily dose of 0.03 mg/d lead in drinking water. This concentration far exceeds the reporting limit for lead of 0.03 mg/L and lead has never been detected at that reporting limit. Therefore, there is no risk from lead for exposure directly to leachate by ingestion or dermal contact.

3.6 Uncertainty Analysis

All risk assessments contain uncertainties. The purpose of the uncertainty analysis is not to remove these uncertainties, but to identify them and predict their effect on the risk assessment results.

There are typical uncertainties that are associated with the underlying toxicity data, which are often extrapolated from animal studies and contain uncertainty factors due to database adequacy. There are also uncertainties because of the receptor parameters as well. In general, the conservative exposure parameters applied are expected to represent any potentially exposed workers.

There are uncertainties regarding the modeling of volatilization from leachate to air during spray application. A simple conservative model was applied which is expected to over-predict air concentrations. Although it is known that the leachate spray is released from a height of 5.5 ft (1.68 m), the volume of air into which the vapors disperse is an unknown. It was assumed that the "box" that defined the air volume and model boundaries was 1 acre to a height of 10 feet (3.05 m) above ground surface. The actual air concentrations could locally be higher if application rate is to a smaller area which thus concentrates the vapors or if the application rate is higher than 3600 gal/ac. Conversely, the actual air concentrations could be much lower if the leachate is applied during even a slightly breezy day which would increase dispersion.

The concentration of VOCs and SVOCs in soils is likely to be over-predicted because the amount lost to the air was not subtracted from the amount falling onto the soil. If the bulk of the chemical concentration is released to the air as predicted by the model, then the amount reaching soil is minimal. Thus, the overall contribution of soil to the RBSL is overly conservative.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Variation in exposure parameters and toxicity values since 1998 produces different results in the risk numbers. Figure 2 shows how the receptor-specific parameters differ between standard EPA default values, values used in the 2008/1998 Analysis, and this site-specific 2009 risk assessment. Some values are lower, and others higher. This indicates that differences in the RBSLs may not be straight-forward.

The current analysis brought the toxicity values up to date. Some values increased, some decreased, and some have been discontinued since the original 1998 Risk Assessment. This too affects the RBSLs.

It appears that the original analysis used for the delisting petition remains conservative and protective, because re-evaluation using site-specific and realistic exposure parameters, despite the fact that additional potentially complete exposure pathways are included in the analysis, results in higher RBSLs than those developed in 2008 using the toxicity and risk assessment assumptions from the 1998 Risk Assessment.

The RBSLs based on the site-specific 2009 parameters indicate that the leachate is safe to apply, and that there is no risk to workers at a target cancer risk of 10^{-6} and a target hazard quotient for noncancer effects of one. Further, these RBSLs assume that no PPE is worn even though workers are required to wear standard level D protection.

For most SVOCs and VOCs, volatilization from the leachate as it is applied is predicted to result in the lowest RBSL (i.e., be the most conservative pathway). Note that these results are based on a highly conservative screening model that does not account for wind movement that would dilute the potential air concentration.

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TABLES AND FIGURES

Table 1. Potentially Complete Exposure Pathways Evaluated as a Component of the RBSLs	
Medium	**Industrial Land Use**
Leachate	Incidental Ingestion Dermal absorption Inhalation of volatiles emanating from spray
Soil	Incidental Ingestion Inhalation of particulates Inhalation of volatiles emanating from soil Dermal absorption

Table 2. Receptor-Specific Exposure Parameters Used in the RBSL Equations					
Exposure Type	**Parameter Name and Units**	**Abbreviation**	**EPA Default Worker**	**2008/1998 Industrial Worker**	**2009 Site-Specific Industrial Worker**
General	Adult Body Weight (kg)	BWa	70	70	70
	Exposure Frequency (d/yr)	EF	250	60	4
	Exposure Duration-Adult (yr)	ED	25	10	30
	Exposure Time (hr/d)	ET	8	8	0.33
	Number of Events Daily (unitless)	EV	1	1	1
	Averaging Time - Cancer (days)	ATc	25550	25550	25550
	Averaging Time Adult - Noncancer (ED*365)	ATnc	9125	3650	3650
	Target Hazard Quotient (unitless)	THQ	1	1	1
	Target Risk (unitless)	TR	1.00E-06	1.00E-06	1.00E-06
	Cancer Slope Factor, oral $(mg/kg\text{-}d)^{-1}$	CSFo	Varies	Varies	Varies
	Cancer Slope Factor, inhalation $(mg/kg\text{-}d)^{-1}$	CSFi	NA	Varies	NA
	Inhalation Unit Risk $(ug/m^3)^{-1}$	IUR	Varies	Varies	Varies
	Noncancer Reference Dose (mg/kg-d)	RfD	Varies	Varies	Varies
	Noncancer Inhalation Reference Dose (mg/kg-d)	RfDi	NA	Varies	NA
	Reference Concentration (mg/m^3)	RfC	Varies	Varies	Varies
Conversion Factors	Volumetric Conversion Factor (L/cm^3)	CFw	1.00E-03	1.00E-03	1.00E-03
	Mass Conversion Factor (mg/kg)	CF1	1.00E+06	1.00E+06	1.00E+06
	Time Conversion Factor (d/h)	CFt	0.04	0.04	0.04
	Mass Conversion Factor (kg/mg)	CF2	1.00E-06	1.00E-06	1.00E-06
	Mass Conversion Factor (mg/ug)	CF3	1.00E-03	1.00E-03	1.00E-03
Leachate Ingestion and Dermal Contact and Inhalation	Leachate Concentration (ug/L)	CL	Varies	Varies	Varies
	Event Time (hr)	t_{event}	0.58	8	0.33
	Hourly Incidental Leachate Ingestion Rate (L/h)	CR_h	0.05 [a]	0.001	0.005
	Daily Incidental Leachate Ingestion Rate (L/d)	CR_d	0.4[a]	NA	0.0017
	Surface Area - Adult (cm^2)	SAw	3300	4700	3300
	Permeability Constant	PC	Varies	Varies	Varies
Soil Ingestion, Dermal Contact, and Inhalation	Estimated Soil Concentration Following Leachate	Csoil	Varies	Varies	Varies
	Particulate Emission Factor (m^3/kg)	PEF	1.40E+09	4.63E+09	6.1E+08[b]
	Volatilization Factor (m^3/kg)	VFs	Varies	Varies	Varies
	Soil Ingestion Rate - Adults (mg/d)	IRS	100	480	100
	Gastrointestinal Absorption Factor	GIABS	Varies	NA	Varies
	Surface Area - Adult (cm^2) [c]	SA	3300	4700	3300
	Adherence Factor - Adult (mg/cm^2)	AF	0.2	1	0.2
	Skin Absorption (unitless)	ABS	Varies	0.50	Varies
	Inhalation Rate - Adult (m^3/h)	IRA	NA	0.83	NA

Notes:
NA – Not applicable
EPA values are from EPA (2008) unless otherwise noted below:

a. *A standard parameter is lacking. Value shown based on incidental ingestion during swimming is 50 ml/hr as a default (EPA, 1989) * 8 hr/d. A current site value of 5 ml/hr (1 teaspoon) for the 18 minute exposure (rounded up to 20 minutes or 0.33 hr) is shown.*
b. *Denver CO, 10 acre site, Q/Cwind is 42.1486 (EPA, 2008 Calculator)*
c. *Units were cm^2/day, now are cm^2*

Table 3. Toxicity Values							
	2008/1998 Risk Assessment			2009 Risk Assessment			
Analyte	CSFo (mg/kg-day)$^{-1}$	IUR (ug/m^3)$^{-1}$	RfD (mg/kg-day)	CSFo (mg/kg-day)$^{-1}$	IUR (ug/m^3)$^{-1}$	RfD (mg/kg-day)	RfC (mg/m^3)
Arsenic	1.5E+00	4.3E-03	3.0E-04	1.5E+00	4.3E-03	3.0E-04	3.0E-05C
Barium			7.0E-02			2.0E-01	5.0E-04H
Benzene	2.9E-02	8.3E-06		5.5E-02	7.8E-06	4.0E-03	3.0E-02
Cadmium (Diet)	6.3E+00	1.8E-03	1.0E-03		1.8E-03	1.0E-03	
Cadmium (Water)			5.0E-04		1.8E-03	5.0E-04	
Carbon Tetrachloride	1.3E-01	1.5E-05	7.0E-04	1.3E-01	1.5E-05	7.0E-04	1.9E-01A
Chlordane	1.3E+00	3.7E-04	6.5E-05	3.5E-01	1.0E-04	5.0E-04	7.0E-04
Chlorobenzene			2.0E-02			2.0E-02	5.0E-02P
Chloroform	6.1E-03	2.3E-05	1.0E-02	3.1E-02	2.3E-05	1.0E-02	9.8E-02A
Chromium (III)			1.0E+00			1.5E+00	
Cresol, m-						5.0E-02	
Cresol, o-						5.0E-02	
Cresol, p-						5.0E-03H	
Hydrogen Cyanide			2.0E-02			2.0E-02	3.0E-03
Dichlorobenzene, 1,4-			8.0E-01	5.4E-03C	1.1E-05C		8.0E-01
Dichloroethane, 1,2-	9.1E-02	2.6E-05		9.1E-02	2.6E-05	2.0E-02P	2.4E+00A
Dichloroethylene, 1,1-	6.0E-01	5.0E-05	9.0E-03			5.0E-02	2.0E-01
Dichlorophenoxy Acetic Acid, 2,4-			1.0E-02			1.0E-02	
Dinitrotoluene, 2,4-			2.0E-03			2.0E-03	
Endrin			3.0E-04			3.0E-04	
Heptachlor	4.5E+00	1.3E-03	5.0E-04	4.5E+00	1.3E-03	5.0E-04	
Heptachlor Epoxide	9.1E+00	2.6E-03	1.3E-05	9.1E+00	2.6E-03	1.3E-05	
Hexachlorobenzene	1.6E+00	4.6E-04	8.0E-04	1.6E+00	4.6E-04	8.0E-04	
Hexachlorobutadiene	7.8E-02	2.2E-05		7.8E-02	2.2E-05	1.0E-03 P	
Hexachlorocyclohexane, Gamma- (Lindane)			3.0E-04	1.1E+00 C	3.1E-04 C	3.0E-04	
Hexachloroethane	1.4E-02	4.0E-06	1.0E-03	1.4E-02	4.0E-06	1.0E-03	
Lead							
Mercury (value for HgCl)			3.0E-04			3.0E-04	
Methoxychlor			5.0E-03			5.0E-03	
Methyl Ethyl Ketone (2-Butanone)			6.0E-01			6.0E-01	5.0E+00
Nickel			2.0E-02			2.0E-02	
Nitrobenzene			5.0E-04			5.0E-04	2.0E-03H
Pentachlorophenol	1.2E-01	3.4E-05	3.0E-02	1.2E-01		3.0E-02	
Pyridine			1.0E-03			1.0E-03	
Selenium			5.0E-03			5.0E-03	
Silver			5.0E-03			5.0E-03	
Tetrachloroethylene			1.0E-02	5.4E-01C	5.9E-06 C	1.0E-02	2.7E-01A
Thallium			8.0E-05			6.5E-05S	
Toxaphene	1.1E+00	3.2E-04		1.1E+00	3.2E-04		
Trichloroethylene				1.3E-02C	2.0E-06C		
Trichlorophenol, 2,4,5-			1.0E-01			1.0E-01	
Trichlorophenol, 2,4,6-	1.1E-02	3.1E-06		1.1E-02	3.1E-06	1.0E-03P	
Trichlorophenoxy) Propionic Acid, 2(2,4,5-			8.0E-03			8.0E-03	
Vinyl Chloride	1.9E+00			7.2E-01	4.4E-06	3.0E-03	1.0E-01

Notes:
The source of these toxicity values is EPA (2008). All values were obtained by EPA from IRIS unless otherwise indicated by EPA (2008) as follows: C- California EPA; P – PPRTV ; H – HEAST; S - The oral RfD for thallium was derived from the IRIS oral RfD for thallium sulfate by factoring out the molecular weight (MW) of the sulfate ion. Thallium sulfate (Tl2S04) has a molecular weight of 504.82. The two atoms of thallium contribute 81% of the MW. Thallium sulfate's oral RfD of 8E-05 multiplied by 81% gives a thallium oral RfD of 6.48E-05 (EPA, 2008, User's Guide, Section 5); A –ATSDR
Blank cells indicate data are lacking.

Table 4. Chemical Specific Parameters Used in the Current Soil RBSL Equations									
Analyte Name	**Henry's Law Constant (H') (cm^3/cm^3)**	**Diffusivity in Air (Dia) (cm^2/s)**	**Diffusivity in Water (Diw) (cm^2/s)**	**Soil-Water Partition Coefficient (Koc) (cm^3/g)**	**Apparent Diffusivity (DA)**	**VFs @ 1 ac (m^3/kg)**	**Dermal Permeability Constant (Kp) (cm/h)**	**GIABS**	**Vleach (Eq 21)**
Arsenic, Inorganic					NA	NA	1.00E-03	1.0	NA
Barium					NA	NA	1.00E-03	0.1	NA
Benzene	2.30E-01	9.00E-02	1.00E-05	165.5	9.44E-04	3.93E+03	1.49E-02	1.0	1.10E-03
Benzene	2.28E-01	8.80E-02	9.80E-06	66	1.93E-03	2.75E+03	1.49E-02	1.0	1.10E-03
Cadmium (Diet)					NA	NA	1.00E-03	0.025	NA
Cadmium (Water)					NA	NA	1.00E-03	0.05	NA
Carbon Tetrachloride	1.10E+00	5.70E-02	9.80E-06	48.64	5.44E-03	1.64E+03	1.63E-02	1.0	1.10E-03
Chlordane	2.00E-03			86650	NA	NA	3.78E-02	1.0	7.11E-04
Chlorobenzene	1.30E-01	7.20E-02	9.50E-06	268	2.80E-04	7.21E+03	2.82E-02	1.0	1.09E-03
Chloroform	1.50E-01	7.70E-02	1.10E-05	35.04	1.77E-03	2.87E+03	6.83E-03	1.0	1.10E-03
Chromium (III) (Insoluble Salts)					NA	NA	1.00E-03	0.0	NA
Cresol, m-	3.50E-05	7.30E-02	9.30E-06	434	7.12E-08	4.52E+05	7.77E-03	1.0	3.39E-05
Cresol, o-	4.90E-05	7.30E-02	9.30E-06	443.1	8.89E-08	4.05E+05	7.66E-03	1.0	4.69E-05
Cresol, p-	4.10E-05	7.20E-02	9.20E-06	434	7.85E-08	4.31E+05	7.66E-03	1.0	3.95E-05
Hydrogen Cyanide	5.40E-03	1.70E-01	1.70E-05		NA	NA	1.00E-03	1.0	9.16E-04
Dichlorobenzene, 1,4-	9.90E-02	5.50E-02	8.70E-06	434	1.04E-04	1.19E+04	4.20E-02	1.0	1.09E-03
Dichloroethane, 1,2-	4.80E-02	8.60E-02	1.10E-05	43.79	5.75E-04	5.03E+03	4.20E-03	1.0	1.08E-03
Dichloroethylene, 1,1-	1.10E+00	8.60E-02	1.10E-05	35.04	9.50E-03	1.24E+03	1.17E-02	1.0	1.10E-03
Dichlorophenoxy Acetic Acid, 2,4-	1.40E-06			29.41	NA	NA	NA	1.0	1.40E-06
Dinitrotoluene, 2,4-	2.20E-06			363.8	NA	NA	3.08E-03	1.0	2.20E-06
Endrin	2.60E-04			10600	NA	NA	1.22E-02	1.0	2.10E-04
Heptachlor	1.20E-02			52410	NA	NA	8.64E-03	1.0	1.01E-03
Heptachlor Epoxide	8.60E-04			5260	NA	NA	NA	1.0	4.83E-04
Hexachlorobenzene	7.00E-02			3380	NA	NA	1.34E-01	1.0	1.09E-03
Hexachlorobutadiene	4.20E-01			993.5	NA	NA	8.09E-02	1.0	1.10E-03
Hexachlorocyclohexane, Gamma- (Lindane)	2.10E-04			3380	NA	NA	1.08E-02	1.0	1.76E-04
Hexachloroethane	1.60E-01			224.7	NA	NA	3.01E-02	1.0	1.10E-03
Lead and Compounds					NA	NA	NA	1.0	NA
Methoxychlor	8.30E-06			42550	NA	NA	NA	1.0	8.24E-06
Methyl Ethyl Ketone (2-Butanone)	2.30E-03	9.10E-02	1.00E-05	3.827	8.84E-05	1.28E+04	9.63E-04	1.0	7.46E-04
Mercuric Chloride					NA	NA	1.00E-03	0.1	NA
Nickel Soluble Salts					NA	NA	2.00E-04	0.04	NA
Nitrobenzene	9.80E-04	6.80E-02	9.40E-06	190.8	2.82E-06	7.18E+04	NA	1.0	5.19E-04
Pentachlorophenol	1.00E-06			3380	NA	NA	3.93E-01	1.0	9.99E-07
Pyridine	4.50E-04	9.30E-02	1.10E-05	33.01	7.51E-06	4.40E+04	NA	1.0	3.20E-04
Selenium					NA	NA	1.00E-03	1.0	NA

Table 4. Chemical Specific Parameters Used in the Current Soil RBSL Equations									
Analyte Name	**Henry's Law Constant (H') (cm^3/cm^3)**	**Diffusivity in Air (Dia) (cm^2/s)**	**Diffusivity in Water (Diw) (cm^2/s)**	**Soil-Water Partition Coefficient (Koc) (cm^3/g)**	**Apparent Diffusivity (DA)**	**VFs @ 1 ac (m^3/kg)**	**Dermal Permeability Constant (Kp) (cm/h)**	**GIABS**	**Vleach (Eq 21)**
Silver					NA	NA	6.00E-04	0.04	NA
Tetrachloroethylene	7.20E-01	5.00E-02	9.50E-06	106.8	2.13E-03	2.614E+03	3.34E-02	1.0	1.10E-03
Thallium (Soluble Salts)					NA	NA	1.00E-03	1.0	NA
Toxaphene	2.50E-04			99300	NA	NA	1.19E-02	1.0	2.04E-04
Trichloroethylene	4.00E-01	6.90E-02	1.00E-05	67.7	2.46E-03	2.43E+03	1.16E-02	1.0	1.10E-03
Trichlorophenol, 2,4,5-	6.60E-05	5.60E-02	6.50E-06	1186	3.23E-08	6.71E+05	NA	1.0	6.23E-05
Trichlorophenol, 2,4,6-	1.10E-04	3.10E-02	8.10E-06	1186	3.17E-08	6.77E+05	3.50E-02	1.0	1.00E-04
Trichlorophenoxy) Propionic Acid, 2(2,4,5-	3.70E-07			80.4	NA	NA	NA	1.0	3.70E-07
Vinyl Chloride	1.10E+00	1.10E-01	1.20E-05	23.74	1.40E-02	1.02E+03	5.60E-03	1.0	1.10E-03

Notes:
NA – Not available

Source:
Vleach, D_A and VFs are calculated with equations presented in the text. Other parameters were obtained from EPA, 2008. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/xls/params_sl_table_run_12SEP2008.xls

Table 5. Permeability Coefficients Used in the 2008/ 1998 Risk Assessment		
Analyte	**CAS**	**PC (cm/h)**
1,1-Dichloroethylene	75-35-4	1.60E-02
1,2-Dichloroethane	107-06-2	5.30E-03
1,4-Dichlorobenzene	106-46-7	6.20E-02
2,4,5-TP (Silvex)	93-72-1	1.00E-02
Cresol, m-	108-39-4	1.00E-02
Cresol, o-	95-48-7	1.00E-02
Cresol, p-	106-44-5	1.00E-02
Arsenic	7440-38-2	1.00E-03
Barium	7440-39-3	1.00E-03
Benzene	71-43-2	2.10E-02
Butadiene, 1,3-	106-99-0	2.30E-02
Cadmium	7440-43-9	1.00E-03
Carbon tetrachloride	56-23-5	2.20E-02
Chlordane	57-74-9	5.20E-02
Chlorobenzene	108-90-7	4.10E-02
Chloroform	67-66-3	8.90E-03
Chromium	16065-83-1	1.00E-03
Cyanide (hydrogen)	74-90-8	1.00E-03
Dichlorophenoxy Acetic Acid, 2,4-	94-75-7	1.00E-02
Dinitrotoluene, 2,4-	121-14-2	3.80E-03
Endrin	72-20-8	1.60E-02
gamma-BHC (Lindane; Hexachlorocyclohexane)	58-89-9	1.40E-02
Heptachlor	76-44-8	1.10E-02
Heptachlor epoxide	1024-57-3	1.10E-02
Hexachlorobenzene	118-74-1	2.10E-01
Hexachlorobutadiene	87-68-3	1.20E-01
Hexachloroethane	67-72-1	4.20E-02
Mercury	7487-94-7	1.00E-03
Methoxychlor	72-43-5	1.00E-02
Methyl ethyl ketone (2-Butanone)	78-93-3	1.10E-03
Nitrobenzene	98-95-3	1.00E-02
Nickel	7440-02-0	1.00E-03
Pentachlorophenol	87-86-5	6.50E-01
Pyridine	110-86-1	1.00E-02
Selenium	7782-49-2	1.00E-03
Silver	7440-22-4	1.00E-03
Tetrachloroethylene (PCE)	127-18-4	4.80E-02
Thallium	7440-28-0	1.00E-03
Toxaphene	8001-35-2	1.50E-02
Trichloroethylene (TCE)	79-01-6	1.60E-02
Trichlorophenol, 2,4,5-	95-95-4	1.01E+00
Trichlorophenol, 2,4,6-	88-06-2	5.00E-02
Vinyl chloride	75-01-4	7.30E-03

Table 6. Soil RBSLs Based on a Cancer Endpoint												
	EPA Default				2008/1998				2009			
Analyte	Soil Ingestion (mg/kg)	Dermal Contact with Soils (mg/kg)	Inhalation (mg/kg)	Total Soil (mg/kg)	Soil Ingestion (mg/kg)	Dermal Contact with Soils (mg/kg)	Inhalation (mg/kg)	Total Soil (mg/kg)	Soil Ingestion (mg/kg)	Dermal Contact with Soils (mg/kg)	Inhalation (mg/kg)	Total Soil (mg/kg)
VOCs												
Benzene	5.2E+01	No ABS	6.18E+00	5.5E+00	1.1E+02	No ABS	6.43E+01	4.1E+01	2.7E+03	No ABS	7.80E+03	2.0E+03
2-Butanone (MEK)	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Carbon Tetrachloride	2.2E+01	No ABS	1.34E+00	1.26E+00	4.8E+01	No ABS	1.39E+01	1.08E+01	1.1E+03	No ABS	1.69E+03	6.83E+02
Chlorobenzene	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Chloroform	9.2E+01	No ABS	1.53E+00	1.50E+00	2.0E+02	No ABS	1.59E+01	1.48E+01	4.8E+03	No ABS	1.93E+03	1.38E+03
1,2-Dichloroethane	3.1E+01	No ABS	2.37E+00	2.21E+00	6.8E+01	No ABS	2.47E+01	1.81E+01	1.6E+03	No ABS	3.00E+03	1.06E+03
1,1-Dichloroethene	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Tetrachloroethene	5.3E+00	No ABS	5.43E+00	2.68E+00	1.2E+01	No ABS	5.66E+01	9.56E+00	2.8E+02	No ABS	6.86E+03	2.65E+02
Trichloroethene	2.2E+02	No ABS	1.49E+01	1.40E+01	4.8E+02	No ABS	1.55E+02	1.17E+02	1.1E+04	No ABS	1.88E+04	7.13E+03
Vinyl Chloride	4.0E+00	No ABS	2.84E+00	1.66E+00	8.6E+00	No ABS	2.96E+01	6.68E+00	2.1E+02	No ABS	3.59E+03	1.96E+02
SVOCs												
Dichlorobenzene, 1,4-	5.3E+02	No ABS	1.32E+01	1.29E+01	1.2E+03	No ABS	1.38E+02	1.23E+02	2.8E+04	No ABS	1.67E+04	1.04E+04
Dinitrotoluene, 2,4-	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Hexachlorobutadiene	3.7E+01	5.56E+01	7.80E+05	2.21E+01	8.0E+01	8.13E+01	2.69E+07	4.02E+01	1.9E+03	2.90E+03	4.29E+08	1.15E+03
Hexachloroethane	2.0E+02	3.10E+02	4.29E+06	1.23E+02	4.4E+02	4.53E+02	1.48E+08	2.24E+02	1.1E+04	1.61E+04	2.36E+09	6.41E+03
Nitrobenzene	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Pentachlorophenol	2.4E+01	1.45E+01	NA	9.00E+00	5.2E+01	2.11E+01	NA	1.50E+01	1.2E+03	7.53E+02	NA	4.69E+02
Pyridine	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Cresol, m-	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Cresol, o-	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Cresol, p-	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Pesticides												
2,4,5-TP (Silvex)	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
2,4-D (Dichlorophenoxy Acetic Acid)	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Chlordane	8.2E+00	3.10E+01	1.72E+05	6.47E+00	1.8E+01	4.53E+01	5.91E+06	1.27E+01	4.3E+02	1.61E+03	9.45E+07	3.37E+02
Endrin	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
gamma-BHC (Lindane; Hexachlorocyclohexane)	2.6E+00	9.85E+00	5.54E+04	2.06E+00	5.6E+00	1.44E+01	1.91E+06	4.06E+00	1.4E+02	5.13E+02	3.05E+07	1.07E+02
Heptachlor	6.4E-01	9.64E-01	1.32E+04	3.83E-01	1.4E+00	1.41E+00	4.55E+05	6.97E-01	3.3E+01	5.02E+01	7.27E+06	2.00E+01
Heptachlor epoxide	3.1E-01	4.76E-01	6.60E+03	1.89E-01	6.8E-01	6.97E-01	2.27E+05	3.45E-01	1.6E+01	2.48E+01	3.63E+06	9.87E+00
Hexachlorobenzene	1.8E+00	2.71E+00	3.73E+04	1.08E+00	3.9E+00	3.96E+00	1.29E+06	1.96E+00	9.3E+01	1.41E+02	2.05E+07	5.61E+01

Table 6. Soil RBSLs Based on a Cancer Endpoint												
	EPA Default				2008/1998				2009			
Analyte	**Soil Ingestion (mg/kg)**	**Dermal Contact with Soils (mg/kg)**	**Inhalation (mg/kg)**	**Total Soil (mg/kg)**	**Soil Ingestion (mg/kg)**	**Dermal Contact with Soils (mg/kg)**	**Inhalation (mg/kg)**	**Total Soil (mg/kg)**	**Soil Ingestion (mg/kg)**	**Dermal Contact with Soils (mg/kg)**	**Inhalation (mg/kg)**	**Total Soil (mg/kg)**
Methoxychlor	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Toxaphene	2.6E+00	3.94E+00	5.37E+04	1.57E+00	5.6E+00	5.77E+00	1.85E+06	2.85E+00	1.4E+02	2.05E+02	2.95E+07	8.16E+01
Trichlorophenol, 2,4,5-	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Trichlorophenol, 2,4,6-	2.6E+02	3.94E+02	2.68E+03	1.48E+02	5.6E+02	5.77E+02	2.79E+04	2.82E+02	1.4E+04	2.05E+04	3.38E+06	8.14E+03
Inorganics												
Arsenic	1.9E+00	9.64E+00	3.99E+03	1.59E+00	4.1E+00	1.41E+01	1.38E+05	3.20E+00	9.9E+01	5.02E+02	2.20E+06	8.29E+01
Barium	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Cadmium	No CSF	No CSF	9.54E+03	9.54E+03	No CSF	No CSF	3.29E+05	3.29E+05	No CSF	No CSF	5.25E+06	5.25E+06
Chromium	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Lead	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Mercury	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Nickel	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Selenium	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Silver	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Thallium	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Total Cyanide	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA

Notes: NA- Not available. See Table 2 for definitions of other parameters. Inhalation RBSL includes particulates and volatiles.

Table 7. Soil RBSLs Based on a Noncancer Endpoint

Analyte	EPA Default				2008/1998				2009			
	Soil Ingestion (mg/kg)	Dermal Contact with Soils (mg/kg)	Inhalation (mg/kg)	Total Soil (mg/kg)	Soil Ingestion (mg/kg)	Dermal Contact with Soils (mg/kg)	Inhalation (mg/kg)	Total Soil (mg/kg)	Soil Ingestion (mg/kg)	Dermal Contact with Soils (mg/kg)	Inhalation (mg/kg)	Total Soil (mg/kg)
VOCs												
Benzene	4.1E+03	No ABS	5.16E+02	4.6E+02	3.5E+03	No ABS	2.15E+03	1.3E+03	2.6E+05	No ABS	7.82E+05	1.9E+05
2-Butanone (MEK)	6.1E+05	No ABS	2.81E+05	1.93E+05	5.3E+05	No ABS	1.17E+06	3.66E+05	3.8E+07	No ABS	4.26E+08	3.52E+07
Carbon Tetrachloride	7.2E+02	No ABS	1.36E+03	4.69E+02	6.2E+02	No ABS	5.67E+03	5.60E+02	4.5E+04	No ABS	2.06E+06	4.38E+04
Chlorobenzene	2.0E+04	No ABS	1.58E+03	1.47E+03	1.8E+04	No ABS	6.58E+03	4.80E+03	1.3E+06	No ABS	2.39E+06	8.33E+05
Chloroform	1.0E+04	No ABS	1.23E+03	1.10E+03	8.9E+03	No ABS	5.13E+03	3.25E+03	6.4E+05	No ABS	1.87E+06	4.76E+05
1,2-Dichloroethane	2.0E+04	No ABS	5.29E+04	1.47E+04	1.8E+04	No ABS	2.20E+05	1.64E+04	1.3E+06	No ABS	8.01E+07	1.26E+06
1,1-Dichloroethene	5.1E+04	No ABS	1.08E+03	1.06E+03	4.4E+04	No ABS	4.52E+03	4.10E+03	3.2E+06	No ABS	1.64E+06	1.08E+06
Tetrachloroethene	1.0E+04	No ABS	3.09E+03	2.37E+03	8.9E+03	No ABS	1.29E+04	5.25E+03	6.388E+05	No ABS	4.68E+06	5.62E+05
Trichloroethene	No RfD	No RfD	No RFC	NA	No RfD	No RfD	No RFC	NA	No RfD	No RfD	No RFC	NA
Vinyl Chloride	3.1E+03	No ABS	4.47E+02	3.90E+02	2.7E+03	No ABS	1.86E+03	1.10E+03	1.9E+05	No ABS	6.77E+05	1.49E+05
SVOCs												
Dichlorobenzene, 1,4-	No RfD	No RfD	4.15E+04	4.15E+04	No RfD	No RfD	1.73E+05	1.73E+05	No RfD	No RfD	6.29E+07	6.29E+07
Dinitrotoluene, 2,4-	2.0E+03	3.04E+03	No RFC	1.22E+03	1.8E+03	1.78E+03	No RFC	8.88E+02	1.3E+05	1.90E+05	No RFC	7.64E+04
Hexachlorobutadiene	1.0E+03	1.55E+03	No RFC	6.16E+02	8.9E+02	9.06E+02	No RFC	4.48E+02	6.4E+04	9.68E+04	No RFC	3.85E+04
Hexachloroethane	1.0E+03	1.55E+03	No RFC	6.16E+02	8.9E+02	9.06E+02	No RFC	4.48E+02	6.4E+04	9.68E+04	No RFC	3.85E+04
Nitrobenzene	5.1E+02	No ABS	6.29E+02	2.82E+02	4.4E+02	No ABS	2.62E+03	3.79E+02	3.2E+04	No ABS	9.53E+05	3.09E+04
Pentachlorophenol	3.1E+04	1.86E+04	No RFC	1.16E+04	2.7E+04	1.09E+04	No RFC	7.72E+03	1.9E+06	1.16E+06	No RFC	7.23E+05
Pyridine	1.0E+03	No ABS	No RFC	1.02E+03	8.9E+02	No ABS	No RFC	8.87E+02	6.4E+04	No ABS	No RFC	6.39E+04
Cresol, m-	5.1E+04	7.74E+04	No RFC	3.08E+04	4.4E+04	4.53E+04	No RFC	2.24E+04	3.2E+06	4.84E+06	No RFC	1.92E+06
Cresol, o-	5.1E+04	7.74E+04	No RFC	3.08E+04	4.4E+04	4.53E+04	No RFC	2.24E+04	3.2E+06	4.84E+06	No RFC	1.92E+06
Cresol, p-	5.1E+03	7.74E+03	No RFC	3.08E+03	4.4E+03	4.53E+03	No RFC	2.24E+03	3.2E+05	4.84E+05	No RFC	1.92E+05
Pesticides												
2,4,5-TP (Silvex)	8.2E+03	1.24E+04	No RFC	4.93E+03	7.1E+03	7.25E+03	No RFC	3.59E+03	5.1E+05	7.74E+05	No RFC	3.08E+05
2,4-D (Dichlorophenoxy Acetic Acid)	1.0E+04	3.10E+04	No RFC	7.68E+03	8.9E+03	1.81E+04	No RFC	5.96E+03	6.4E+05	1.94E+06	No RFC	4.80E+05
Chlordane	5.1E+02	1.94E+03	4.29E+06	4.04E+02	4.4E+02	1.13E+03	5.91E+07	3.19E+02	3.2E+04	1.21E+05	2.83E+09	2.53E+04
Endrin	3.1E+02	4.65E+02	No RFC	1.85E+02	2.7E+02	2.72E+02	No RFC	1.34E+02	1.9E+04	2.90E+04	No RFC	1.15E+04
gamma-BHC (Lindane; Hexachlorocyclohexane)	3.1E+02	1.16E+03	No RFC	2.43E+02	2.7E+02	6.80E+02	No RFC	1.91E+02	1.9E+04	7.26E+04	No RFC	1.52E+04
Heptachlor	5.1E+02	7.74E+02	No RFC	3.08E+02	4.4E+02	4.53E+02	No RFC	2.24E+02	3.2E+04	4.84E+04	No RFC	1.92E+04
Heptachlor epoxide	1.3E+01	2.01E+01	No RFC	8.00E+00	1.2E+01	1.18E+01	No RFC	5.83E+00	8.3E+02	1.26E+03	No RFC	5.00E+02

Table 7. Soil RBSLs Based on a Noncancer Endpoint												
	EPA Default				2008/1998				2009			
Analyte	Soil Ingestion (mg/kg)	Dermal Contact with Soils (mg/kg)	Inhalation (mg/kg)	Total Soil (mg/kg)	Soil Ingestion (mg/kg)	Dermal Contact with Soils (mg/kg)	Inhalation (mg/kg)	Total Soil (mg/kg)	Soil Ingestion (mg/kg)	Dermal Contact with Soils (mg/kg)	Inhalation (mg/kg)	Total Soil (mg/kg)
Hexachlorobenzene	8.2E+02	1.24E+03	No RFC	4.93E+02	7.1E+02	7.25E+02	No RFC	3.59E+02	5.1E+04	7.74E+04	No RFC	3.08E+04
Methoxychlor	5.1E+03	7.74E+03	No RFC	3.08E+03	4.4E+03	4.53E+03	No RFC	2.24E+03	3.2E+05	4.84E+05	No RFC	1.92E+05
Toxaphene	No RfD	No RfD	No RFC	NA	No RfD	No RfD	No RFC	NA	No RfD	No RfD	No RFC	NA
Trichlorophenol, 2,4,5-	1.0E+05	1.55E+05	No RFC	6.16E+04	8.9E+04	9.06E+04	No RFC	4.48E+04	6.4E+06	9.68E+06	No RFC	3.85E+06
Trichlorophenol, 2,4,6-	1.0E+03	1.55E+03	No RFC	6.16E+02	8.9E+02	9.06E+02	No RFC	4.48E+02	6.4E+04	9.68E+04	No RFC	3.85E+04
Inorganics												
Arsenic	3.1E+02	1.55E+03	1.84E+05	2.56E+02	2.7E+02	9.06E+02	2.53E+06	2.06E+02	1.9E+04	9.68E+04	1.21E+08	1.60E+04
Barium	2.0E+05	No ABS	3.07E+06	1.92E+05	1.8E+05	No ABS	4.22E+07	1.77E+05	1.3E+07	No ABS	2.02E+09	1.27E+07
Cadmium	1.0E+03	3.87E+03	No RFC	8.09E+02	8.9E+02	2.27E+03	No RFC	6.37E+02	6.4E+04	2.42E+05	No RFC	5.05E+04
Chromium	1.5E+06	No ABS	No RFC	1.53E+06	1.3E+06	No ABS	No RFC	1.33E+06	9.6E+07	No ABS	No RFC	9.58E+07
Lead	No RfD	No RfD	No RFC	NA	No RfD	No RfD	No RFC	NA	No RfD	No RfD	No RFC	NA
Mercury	3.1E+02	No ABS	No RFC	3.07E+02	2.7E+02	No ABS	No RFC	2.66E+02	1.9E+04	No ABS	No RFC	1.92E+04
Nickel	2.0E+04	No ABS	No RFC	2.04E+04	1.8E+04	No ABS	No RFC	1.77E+04	1.3E+06	No ABS	No RFC	1.28E+06
Selenium	5.1E+03	No ABS	No RFC	5.11E+03	4.4E+03	No ABS	No RFC	4.44E+03	3.2E+05	No ABS	No RFC	3.19E+05
Silver	5.1E+03	No ABS	No RFC	5.11E+03	4.4E+03	No ABS	No RFC	4.44E+03	3.2E+05	No ABS	No RFC	3.19E+05
Thallium	6.6E+01	No ABS	No RFC	6.64E+01	5.8E+01	No ABS	No RFC	5.77E+01	4.2E+03	No ABS	No RFC	4.15E+03
Total Cyanide	2.0E+04	No ABS	1.84E+07	2.04E+04	1.8E+04	No ABS	2.53E+08	1.77E+04	1.3E+06	No ABS	1.21E+10	1.28E+06

Notes: NA- Not available. See Table 2 for definitions of other parameters. Inhalation RBSL includes particulates and volatiles.

Cadmium has a different RfD for the water ingestion versus water dermal and soil exposure pathways

Table 8. Leachate RBSLs Based on a Cancer Endpoint												
	EPA Default				2008/1998				2009			
Analyte	Incidental Ingestion (mg/L)	Leachate Dermal Contact (mg/L)	Inhalation of Volatiles (mg/L)	Total All Pathways (mg/L)	Incidental Ingestion (mg/L)	Leachate Dermal Contact (mg/L)	Inhalation of Volatiles (mg/L)	Total All Pathways (mg/L)	Incidental Ingestion (mg/L)	Leachate Dermal Contact (mg/L)	Inhalation of Volatiles (mg/L)	Total All Pathways (mg/L)
VOCs												
Benzene	1.78E-01	1.82E-01	1.43E-03	1.41E-03	6.77E+00	9.70E-02	1.49E-02	1.29E-02	1.64E+02	1.67E+01	1.79E+00	1.60E+00
2-Butanone (MEK)	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Carbon Tetrachloride	7.55E-02	7.01E-02	7.42E-04	7.27E-04	2.87E+00	3.74E-02	7.73E-03	6.39E-03	6.95E+01	6.45E+00	9.27E-01	8.02E-01
Chlorobenzene	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Chloroform	3.16E-01	7.03E-01	4.87E-04	4.86E-04	1.20E+01	3.75E-01	5.07E-03	5.00E-03	2.91E+02	6.47E+01	6.09E-01	6.02E-01
1,2-Dichloroethane	1.08E-01	3.89E-01	4.37E-04	4.35E-04	4.09E+00	2.08E-01	4.56E-03	4.45E-03	9.93E+01	3.58E+01	5.47E-01	5.36E-01
1,1-Dichloroethene	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Tetrachloroethene	1.82E-02	8.24E-03	1.89E-03	1.42E-03	6.90E-01	4.39E-03	1.97E-02	3.57E-03	1.67E+01	7.58E-01	2.36E+00	5.55E-01
Trichloroethene	7.55E-01	9.83E-01	5.57E-03	5.50E-03	2.87E+01	5.24E-01	5.81E-02	5.22E-02	6.95E+02	9.05E+01	6.97E+00	6.41E+00
Vinyl Chloride	1.36E-02	3.69E-02	2.53E-03	2.02E-03	5.18E-01	1.97E-02	2.63E-02	1.10E-02	1.25E+01	3.40E+00	3.16E+00	1.45E+00
SVOCs												
Dichlorobenzene, 1,4-	1.82E+00	6.56E-01	1.02E-03	1.02E-03	6.90E+01	3.50E-01	1.06E-02	1.03E-02	1.67E+03	6.04E+01	1.28E+00	1.25E+00
Dinitrotoluene, 2,4-	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Hexachlorobutadiene	1.26E-01	2.35E-02	5.07E-04	4.94E-04	4.78E+00	1.26E-02	5.28E-03	3.71E-03	1.16E+02	2.17E+00	6.33E-01	4.88E-01
Hexachloroethane	7.01E-01	3.53E-01	2.80E-03	2.77E-03	2.66E+01	1.88E-01	2.92E-02	2.52E-02	6.45E+02	3.25E+01	3.50E+00	3.14E+00
Nitrobenzene	No CSF	No Kp	No IUR	NA	No CSF	No Kp	No IUR	NA	No CSF	No Kp	No IUR	NA
Pentachlorophenol	8.18E-02	3.15E-03	No IUR	3.03E-03	3.11E+00	1.68E-03	No IUR	1.68E-03	7.53E+01	2.90E-01	No IUR	2.89E-01
Pyridine	No CSF	No Kp	No IUR	NA	No CSF	No Kp	No IUR	NA	No CSF	No Kp	No IUR	NA
Cresol, m-	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Cresol, o-	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Cresol, p-	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
Pesticides												
2,4,5-TP (Silvex)	No CSF	No Kp	No IUR	NA	No CSF	No Kp	No IUR	NA	No CSF	No Kp	No IUR	NA
2,4-D (Dichlorophenoxy Acetic Acid)	No CSF	No Kp	No IUR	NA	No CSF	No Kp	No IUR	NA	No CSF	No Kp	No IUR	NA
Chlordane	2.80E-02	1.12E-02	1.72E-04	1.69E-04	1.06E+00	6.00E-03	1.80E-03	1.38E-03	2.58E+01	1.04E+00	2.16E-01	1.77E-01
Endrin	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA
gamma-BHC (Lindane; Hexachlorocyclohexane)	8.92E-03	1.25E-02	2.24E-04	2.15E-04	3.39E-01	6.66E-03	2.34E-03	1.72E-03	8.21E+00	1.15E+00	2.80E-01	2.19E-01
Heptachlor	2.18E-03	3.82E-03	9.34E-06	9.28E-06	8.28E-02	2.04E-03	9.73E-05	9.27E-05	2.01E+00	3.52E-01	1.17E-02	1.12E-02

Table 8. Leachate RBSLs Based on a Cancer Endpoint												
	EPA Default				2008/1998				2009			
Analyte	Incidental Ingestion (mg/L)	Leachate Dermal Contact (mg/L)	Inhalation of Volatiles (mg/L)	Total All Pathways (mg/L)	Incidental Ingestion (mg/L)	Leachate Dermal Contact (mg/L)	Inhalation of Volatiles (mg/L)	Total All Pathways (mg/L)	Incidental Ingestion (mg/L)	Leachate Dermal Contact (mg/L)	Inhalation of Volatiles (mg/L)	Total All Pathways (mg/L)
Heptachlor epoxide	1.08E-03	No Kp	9.76E-06	9.67E-06	4.09E-02	No Kp	1.02E-04	1.01E-04	9.93E-01	No Kp	1.22E-02	1.21E-02
Hexachlorobenzene	6.13E-03	6.96E-04	2.45E-05	2.36E-05	2.33E-01	3.71E-04	2.56E-04	1.51E-04	5.65E+00	6.40E-02	3.07E-02	2.07E-02
Methoxychlor	No CSF	No Kp	No IUR	NA	No CSF	No Kp	No IUR	NA	No CSF	No Kp	No IUR	NA
Toxaphene	8.92E-03	1.14E-02	1.88E-04	1.81E-04	3.39E-01	6.06E-03	1.96E-03	1.47E-03	8.21E+00	1.05E+00	2.35E-01	1.88E-01
Trichlorophenol, 2,4,5-	No CSF	No Kp	No IUR	NA	No CSF	No Kp	No IUR	NA	No CSF	No Kp	No IUR	NA
Trichlorophenol, 2,4,6-	8.92E-01	3.86E-01	3.96E-02	3.45E-02	3.39E+01	2.06E-01	4.12E-01	1.37E-01	8.21E+02	3.55E+01	4.94E+01	2.02E+01
Inorganics												
Arsenic	6.54E-03	9.91E-02	NA	6.14E-03	2.48E-01	5.29E-02	NA	4.36E-02	6.02E+00	9.12E+00	NA	3.63E+00
Barium	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA
Cadmium	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA
Chromium	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA
Lead	No CSF	No Kp	NA	NA	No CSF	No Kp	NA	NA	No CSF	No Kp	NA	NA
Mercury	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA
Nickel	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA
Selenium	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA
Silver	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA
Thallium	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA	No CSF	No CSF	NA	NA
Total Cyanide	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA	No CSF	No CSF	No IUR	NA

Notes: NA- Not available. See Table 2 for definitions of other parameters.

Table 9. Leachate RBSLs Based on a Noncancer Endpoint												
	EPA Default				2008/1998				2009			
Analyte	Incidental Ingestion (mg/L)	Leachate Dermal Contact (mg/L)	Inhalation of Volatiles (mg/L)	Total All Pathways (mg/L)	Incidental Ingestion (mg/L)	Leachate Dermal Contact (mg/L)	Inhalation of Volatiles (mg/L)	Total All Pathways (mg/L)	Incidental Ingestion (mg/L)	Leachate Dermal Contact (mg/L)	Inhalation of Volatiles (mg/L)	Total All Pathways (mg/L)
VOCs												
Benzene	1.40E+01	1.43E+01	1.20E-01	1.18E-01	2.13E+02	3.05E+00	4.99E-01	4.28E-01	1.55E+04	1.58E+03	1.80E+02	1.60E+02
2-Butanone (MEK)	2.10E+03	3.31E+04	2.94E+01	2.89E+01	3.19E+04	7.06E+03	1.22E+02	1.20E+02	2.32E+06	3.65E+06	4.41E+04	4.27E+04
Carbon Tetrachloride	2.45E+00	2.28E+00	7.55E-01	4.61E-01	3.73E+01	4.86E-01	3.15E+00	4.16E-01	2.71E+03	2.52E+02	1.13E+03	1.91E+02
Chlorobenzene	7.01E+01	3.76E+01	2.00E-01	1.99E-01	1.06E+03	8.03E+00	8.34E-01	7.55E-01	7.74E+04	4.16E+03	3.00E+02	2.79E+02
Chloroform	3.50E+01	7.78E+01	3.92E-01	3.86E-01	5.32E+02	1.66E+01	1.63E+00	1.48E+00	3.87E+04	8.59E+03	5.88E+02	5.43E+02
1,2-Dichloroethane	7.01E+01	2.53E+02	9.75E+00	8.28E+00	1.06E+03	5.40E+01	4.06E+01	2.27E+01	7.74E+04	2.79E+04	1.46E+04	8.54E+03
1,1-Dichloroethene	1.75E+02	2.28E+02	7.95E-01	7.89E-01	2.66E+03	4.86E+01	3.31E+00	3.10E+00	1.94E+05	2.52E+04	1.19E+03	1.13E+03
Tetrachloroethene	3.50E+01	1.59E+01	1.07E+00	9.78E-01	5.32E+02	3.39E+00	4.47E+00	1.92E+00	3.87E+04	1.75E+03	1.61E+03	8.22E+02
Trichloroethene	No RfD	No RfD	No RfC	NA	No RfD	No RfD	No RfC	NA	No RfD	No RfD	No RfC	NA
Vinyl Chloride	1.05E+01	2.85E+01	3.97E-01	3.78E-01	1.60E+02	6.07E+00	1.66E+00	1.29E+00	1.16E+04	3.14E+03	5.96E+02	4.80E+02
SVOCs												
Dichlorobenzene, 1,4-	No RfD	No RfD	3.21E+00	3.21E+00	No RfD	No RfD	1.34E+01	1.34E+01	No RfD	No RfD	4.82E+03	4.82E+03
Dinitrotoluene, 2,4-	7.01E+00	3.44E+01	No RfC	5.82E+00	1.06E+02	7.35E+00	No RfC	6.87E+00	7.74E+03	3.81E+03	No RfC	2.55E+03
Hexachlorobutadiene	3.50E+00	6.56E-01	No RfC	5.53E-01	5.32E+01	1.40E-01	No RfC	1.40E-01	3.87E+03	7.25E+01	No RfC	7.11E+01
Hexachloroethane	3.50E+00	1.76E+00	No RfC	1.17E+00	5.32E+01	3.76E-01	No RfC	3.74E-01	3.87E+03	1.95E+02	No RfC	1.86E+02
Nitrobenzene	1.75E+00	No Kp	1.69E-02	1.67E-02	2.66E+01	No Kp	7.03E-02	7.01E-02	1.94E+03	No Kp	2.53E+01	2.50E+01
Pentachlorophenol	1.05E+02	4.05E+00	No RfC	3.90E+00	1.60E+03	8.64E-01	No RfC	8.64E-01	1.16E+05	4.48E+02	No RfC	4.46E+02
Pyridine	3.50E+00	No Kp	No RfC	3.50E+00	5.32E+01	No Kp	No RfC	5.32E+01	3.87E+03	No Kp	No RfC	3.87E+03
Cresol, m-	1.75E+02	3.41E+02	No RfC	1.16E+02	2.66E+03	7.28E+01	No RfC	7.09E+01	1.94E+05	3.77E+04	No RfC	3.16E+04
Cresol, o-	1.75E+02	3.47E+02	No RfC	1.16E+02	2.66E+03	7.40E+01	No RfC	7.20E+01	1.94E+05	3.83E+04	No RfC	3.20E+04
Cresol, p-	1.75E+01	3.47E+01	No RfC	1.16E+01	2.66E+02	7.40E+00	No RfC	7.20E+00	1.94E+04	3.83E+03	No RfC	3.20E+03
Pesticides												
2,4,5-TP (Silvex)	2.80E+01	No Kp	No RfC	2.80E+01	4.26E+02	No Kp	No RfC	4.26E+02	3.10E+04	No Kp	No RfC	3.10E+04
2,4-D (Dichlorophenoxy Acetic Acid)	3.50E+01	No Kp	No RfC	3.50E+01	5.32E+02	No Kp	No RfC	5.32E+02	3.87E+04	No Kp	No RfC	3.87E+04
Chlordane	1.75E+00	7.03E-01	4.31E-03	4.28E-03	2.66E+01	1.50E-01	1.80E-02	1.60E-02	1.94E+03	7.77E+01	6.47E+00	5.95E+00
Endrin	1.05E+00	1.30E+00	No RfC	5.82E-01	1.60E+01	2.78E-01	No RfC	2.73E-01	1.16E+03	1.44E+02	No RfC	1.28E+02
gamma-BHC (Lindane; Hexachlorocyclohexan	1.05E+00	1.47E+00	No RfC	6.13E-01	1.60E+01	3.14E-01	No RfC	3.08E-01	1.16E+03	1.63E+02	No RfC	1.43E+02

Table 9. Leachate RBSLs Based on a Noncancer Endpoint												
	EPA Default				2008/1998				2009			
Analyte	Incidental Ingestion (mg/L)	Leachate Dermal Contact (mg/L)	Inhalation of Volatiles (mg/L)	Total All Pathways (mg/L)	Incidental Ingestion (mg/L)	Leachate Dermal Contact (mg/L)	Inhalation of Volatiles (mg/L)	Total All Pathways (mg/L)	Incidental Ingestion (mg/L)	Leachate Dermal Contact (mg/L)	Inhalation of Volatiles (mg/L)	Total All Pathways (mg/L)
e)												
Heptachlor	1.75E+00	3.07E+00	No RfC	1.12E+00	2.66E+01	6.55E-01	No RfC	6.39E-01	1.94E+03	3.39E+02	No RfC	2.89E+02
Heptachlor epoxide	4.56E-02	No Kp	No RfC	4.56E-02	6.92E-01	No Kp	No RfC	6.92E-01	5.03E+01	No Kp	No RfC	5.03E+01
Hexachlorobenzene	2.80E+00	3.18E-01	No RfC	2.86E-01	4.26E+01	6.78E-02	No RfC	6.77E-02	3.10E+03	3.51E+01	No RfC	3.47E+01
Methoxychlor	1.75E+01	No Kp	No RfC	1.75E+01	2.66E+02	No Kp	No RfC	2.66E+02	1.94E+04	No Kp	No RfC	1.94E+04
Toxaphene	No RfD	No RfD	No RfC	NA	No RfD	No RfD	No RfC	NA	No RfD	No RfD	No RfC	NA
Trichlorophenol, 2,4,5-	3.50E+02	No Kp	No RfC	3.50E+02	5.32E+03	No Kp	No RfC	5.32E+03	3.87E+05	No Kp	No RfC	3.87E+05
Trichlorophenol, 2,4,6-	3.50E+00	1.52E+00	No RfC	1.06E+00	5.32E+01	3.24E-01	No RfC	3.22E-01	3.87E+03	1.68E+02	No RfC	1.61E+02
Inorganics												
Arsenic	1.05E+00	1.59E+01	NA	9.86E-01	1.60E+01	3.40E+00	NA	2.80E+00	1.16E+03	1.76E+03	NA	7.00E+02
Barium	7.01E+02	1.06E+04	NA	6.57E+02	1.06E+04	2.27E+03	NA	1.87E+03	7.74E+05	1.17E+06	NA	4.66E+05
Cadmium	1.75E+00	5.31E+01	No RfC	1.70E+00	2.66E+01	1.13E+01	No RfC	7.94E+00	1.94E+03	5.87E+03	No RfC	1.46E+03
Chromium	5.26E+03	7.96E+04	No RfC	4.93E+03	7.98E+04	1.70E+04	No RfC	1.40E+04	5.81E+06	8.80E+06	No RfC	3.50E+06
Lead	No RfD	No Kp	No RfC	NA	No RfD	No Kp	No RfC	NA	No RfD	No Kp	No RfC	NA
Mercury	1.05E+00	1.59E+01	No RfC	9.86E-01	1.60E+01	3.40E+00	No RfC	2.80E+00	1.16E+03	1.76E+03	No RfC	7.00E+02
Nickel	7.01E+01	5.31E+03	No RfC	6.92E+01	1.06E+03	1.13E+03	No RfC	5.49E+02	7.74E+04	5.87E+05	No RfC	6.84E+04
Selenium	1.75E+01	2.65E+02	No RfC	1.64E+01	2.66E+02	5.66E+01	No RfC	4.67E+01	1.94E+04	2.93E+04	No RfC	1.17E+04
Silver	1.75E+01	4.42E+02	No RfC	1.69E+01	2.66E+02	9.44E+01	No RfC	6.97E+01	1.94E+04	4.89E+04	No RfC	1.39E+04
Thallium	2.28E-01	3.45E+00	No RfC	2.14E-01	3.46E+00	7.36E-01	No RfC	6.07E-01	2.52E+02	3.81E+02	No RfC	1.52E+02
Total Cyanide	7.01E+01	1.06E+03	1.43E-02	1.43E-02	1.06E+03	2.27E+02	5.98E-02	5.98E-02	7.74E+04	1.17E+05	2.15E+01	2.15E+01

Notes: NA- Not available. See Table 2 for definitions of other parameters.

Table 10. RBSLs for All Potentially Complete Soil and Leachate Pathways Combined						
	Cancer-Based RBSLs (mg/L)			Noncancer-Based RBSLs (mg/L)		
Analyte	EPA Default	2008/1998	2009	EPA Default	2008/1998	2009
VOCs						
Benzene	1.41E-03	1.29E-02	1.60E+00	1.18E-01	4.28E-01	1.60E+02
2-Butanone (MEK)	NA	NA	NA	2.89E+01	1.20E+02	4.27E+04
Carbon Tetrachloride	7.27E-04	6.39E-03	8.02E-01	4.61E-01	4.16E-01	1.91E+02
Chlorobenzene	NA	NA	NA	1.99E-01	7.55E-01	2.79E+02
Chloroform	4.86E-04	5.00E-03	6.02E-01	3.86E-01	1.48E+00	5.43E+02
1,2-Dichloroethane	4.35E-04	4.45E-03	5.36E-01	8.28E+00	2.27E+01	8.54E+03
1,1-Dichloroethene	NA	NA	NA	7.89E-01	3.10E+00	1.13E+03
Tetrachloroethene	1.42E-03	3.57E-03	5.55E-01	9.78E-01	1.92E+00	8.22E+02
Trichloroethene	5.50E-03	5.22E-02	6.41E+00	NA	NA	NA
Vinyl Chloride	2.02E-03	1.10E-02	1.45E+00	3.78E-01	1.29E+00	4.80E+02
SVOCs						
Dichlorobenzene, 1,4-	1.02E-03	1.03E-02	1.25E+00	3.21E+00	1.34E+01	4.82E+03
Dinitrotoluene, 2,4-	NA	NA	NA	5.82E+00	6.87E+00	2.55E+03
Hexachlorobutadiene	4.94E-04	3.71E-03	4.88E-01	5.53E-01	1.40E-01	7.11E+01
Hexachloroethane	2.77E-03	2.52E-02	3.14E+00	1.17E+00	3.74E-01	1.86E+02
Nitrobenzene	NA	NA	NA	1.67E-02	7.01E-02	2.50E+01
Pentachlorophenol	3.03E-03	1.68E-03	2.89E-01	3.90E+00	8.64E-01	4.46E+02
Pyridine	NA	NA	NA	3.50E+00	5.32E+01	3.87E+03
Cresol, m-	NA	NA	NA	1.16E+02	7.09E+01	3.16E+04
Cresol, o-	NA	NA	NA	1.16E+02	7.20E+01	3.20E+04
Cresol, p-	NA	NA	NA	1.16E+01	7.20E+00	3.20E+03
Pesticides						
2,4,5-TP (Silvex)	NA	NA	NA	2.80E+01	4.26E+02	3.10E+04
2,4-D (Dichlorophenoxy Acetic Acid)	NA	NA	NA	3.50E+01	5.32E+02	3.87E+04
Chlordane	1.69E-04	1.38E-03	1.77E-01	4.28E-03	1.60E-02	5.95E+00
Endrin	NA	NA	NA	5.82E-01	2.73E-01	1.28E+02
gamma-BHC (Lindane; Hexachlorocyclohexane)	2.15E-04	1.72E-03	2.19E-01	6.13E-01	3.08E-01	1.43E+02
Heptachlor	9.28E-06	9.27E-05	1.12E-02	1.12E+00	6.39E-01	2.89E+02
Heptachlor epoxide	9.67E-06	1.01E-04	1.21E-02	4.56E-02	6.92E-01	5.03E+01
Hexachlorobenzene	2.36E-05	1.51E-04	2.07E-02	2.86E-01	6.77E-02	3.47E+01
Methoxychlor	NA	NA	NA	1.75E+01	2.66E+02	1.94E+04
Toxaphene	1.81E-04	1.47E-03	1.88E-01	NA	NA	NA
Trichlorophenol, 2,4,5-	NA	NA	NA	3.50E+02	5.32E+03	3.87E+05
Trichlorophenol, 2,4,6-	3.45E-02	1.37E-01	2.02E+01	1.06E+00	3.22E-01	1.61E+02
Inorganics						
Arsenic	6.14E-03	4.36E-02	3.63E+00	9.86E-01	2.80E+00	7.00E+02
Barium	NA	NA	NA	6.57E+02	1.87E+03	4.66E+05
Cadmium	1.04E+14	3.60E+15	5.74E+16	1.70E+00	7.94E+00	1.46E+03
Chromium	NA	NA	NA	4.93E+03	1.40E+04	3.50E+06
Lead	NA	NA	NA	1.50E-02	1.50E-02	1.50E-02
Mercury	NA	NA	NA	9.86E-01	2.80E+00	7.00E+02
Nickel	NA	NA	NA	6.92E+01	5.49E+02	6.84E+04
Selenium	NA	NA	NA	1.64E+01	4.67E+01	1.17E+04

Table 10. RBSLs for All Potentially Complete Soil and Leachate Pathways Combined						
	Cancer-Based RBSLs (mg/L)			Noncancer-Based RBSLs (mg/L)		
Analyte	**EPA Default**	**2008/1998**	**2009**	**EPA Default**	**2008/1998**	**2009**
Silver	NA	NA	NA	1.69E+01	6.97E+01	1.39E+04
Thallium	NA	NA	NA	2.14E-01	6.07E-01	1.52E+02
Total Cyanide	NA	NA	NA	1.43E-02	5.98E-02	2.15E+01

Note:the cadmium cancer RBSL appears extraneous as it reduces to only the exposure due to particulates due to lack of CSFo for oral and dermal evaluation.

Table 11. Comparison of RBSLs to Existing Data					
	Minimum RBSL (cancer or noncancer)[1]				
Analyte	**EPA Default**	**2008/1998**	**2009**	**Primary Sump Site Data [2]**	**Detection Status[3]**
VOCs					
Benzene	0.001	0.013	1.60	***0.010***	ND
2-Butanone (MEK)	28.94	119.86	42736	0.050	ND
Carbon Tetrachloride	0.001	0.006	0.802	***0.010***	ND
Chlorobenzene	0.199	0.755	279	0.010	ND
Chloroform	0.0005	0.005	0.602	***0.010***	ND
1,2-Dichloroethane	0.0004	0.004	0.536	***0.010***	ND
1,1-Dichloroethene	0.79	3.097	1131	0.010	ND
Tetrachloroethene	0.001	0.004	0.555	***0.051***	D
Trichloroethene	0.006	0.052	6.41	***0.012***	D
Vinyl Chloride	0.002	0.011	1.45	***0.020***	ND
SVOCs					
Dichlorobenzene, 1,4-	0.001	0.01	1.25	***0.100***	ND
Dinitrotoluene, 2,4-	5.82	6.87	2551	0.100	ND
Hexachlorobutadiene	0.0005	0.004	0.49	***0.100***	ND
Hexachloroethane	0.003	0.025	3.14	***0.100***	ND
Nitrobenzene	0.017	0.070	24.99	***0.100***	ND
Pentachlorophenol	0.003	0.002	0.29	***0.500***	ND
Pyridine	3.50	53.23	3871	0.100	ND
Cresol, m-	115.79	70.90	31570	0.100	ND
Cresol, o-	116.39	71.96	31976	0.100	ND
Cresol, p-	11.64	7.20	3197	0.100	ND
Pesticides					
2,4,5-TP (Silvex)	28.03	425.83	30969	0.010	ND
2,4-D (Dichlorophenoxy Acetic Acid)	35.04	532.29	38712	0.040	ND
Chlordane	0.0002	0.001	0.18	***0.005***	ND
Endrin	0.58	0.27	128	0.001	ND
gamma-BHC (Lindane; Hexachlorocyclohexane)	0.0002	0.002	0.22	***0.001***	ND
Heptachlor	0.00001	0.0001	0.01	***0.001***	ND
Heptachlor epoxide	0.00001	0.0001	0.01	***0.001***	ND
Hexachlorobenzene	0.00002	0.00015	0.02	***0.100***	ND
Methoxychlor	17.52	266.15	19356	0.001	ND
Toxaphene	0.00018	0.001	0.19	***0.020***	ND
Trichlorophenol, 2,4,5-	350.40	5322.92	387121	0.100	ND
Trichlorophenol, 2,4,6-	0.034	0.14	20	***0.100***	ND
Inorganics					
Arsenic	0.006	0.044	3.63	***0.050***	ND
Barium	657.41	1867.690	466411	0.500	ND
Cadmium	1.70	7.94	1455	0.022	D
Chromium	4930.58	14007.68	3498083	0.010	ND
Lead	18.00	18.00	18	0.030	ND
Mercury	0.99	2.80	700	0.002	ND

Table 11. Comparison of RBSLs to Existing Data					
	Minimum RBSL (cancer or noncancer)[1]				
Analyte	**EPA Default**	**2008/1998**	**2009**	**Primary Sump Site Data [2]**	**Detection Status[3]**
Nickel	69.17	548.75	68396	0.310	D
Selenium	16.44	46.69	11660	0.050	ND
Silver	16.85	69.67	13865	0.100	ND
Thallium	0.21	0.61	152	0.100	ND
Total Cyanide	0.01	0.06	22	***0.024***	D

Notes:
1 – Lowest of cancer or noncancer values
2- The maximum detected value for the Primary Sump from July 29, 2008 or the reporting limit.
3 - D – detected; ND – not detected
Bold italics indicate the detected value or the reporting limit exceed the lowest predicted RBSL.
Shaded cells indicate detected value or the reporting limit exceeds the site-specific RBSL.

Figure 1. Conceptual Site Model for Development of Risk Based Screening Levels (RBSLs)

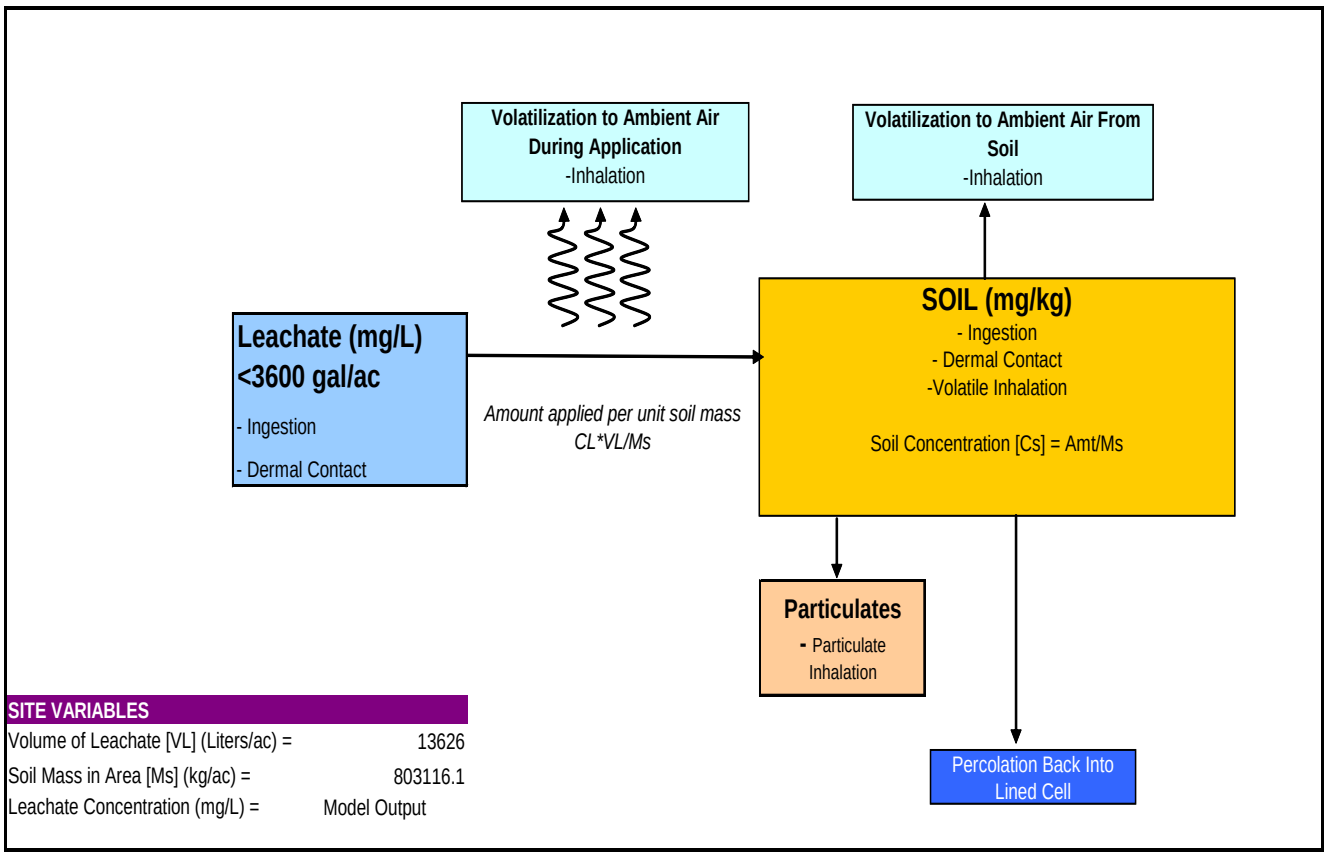
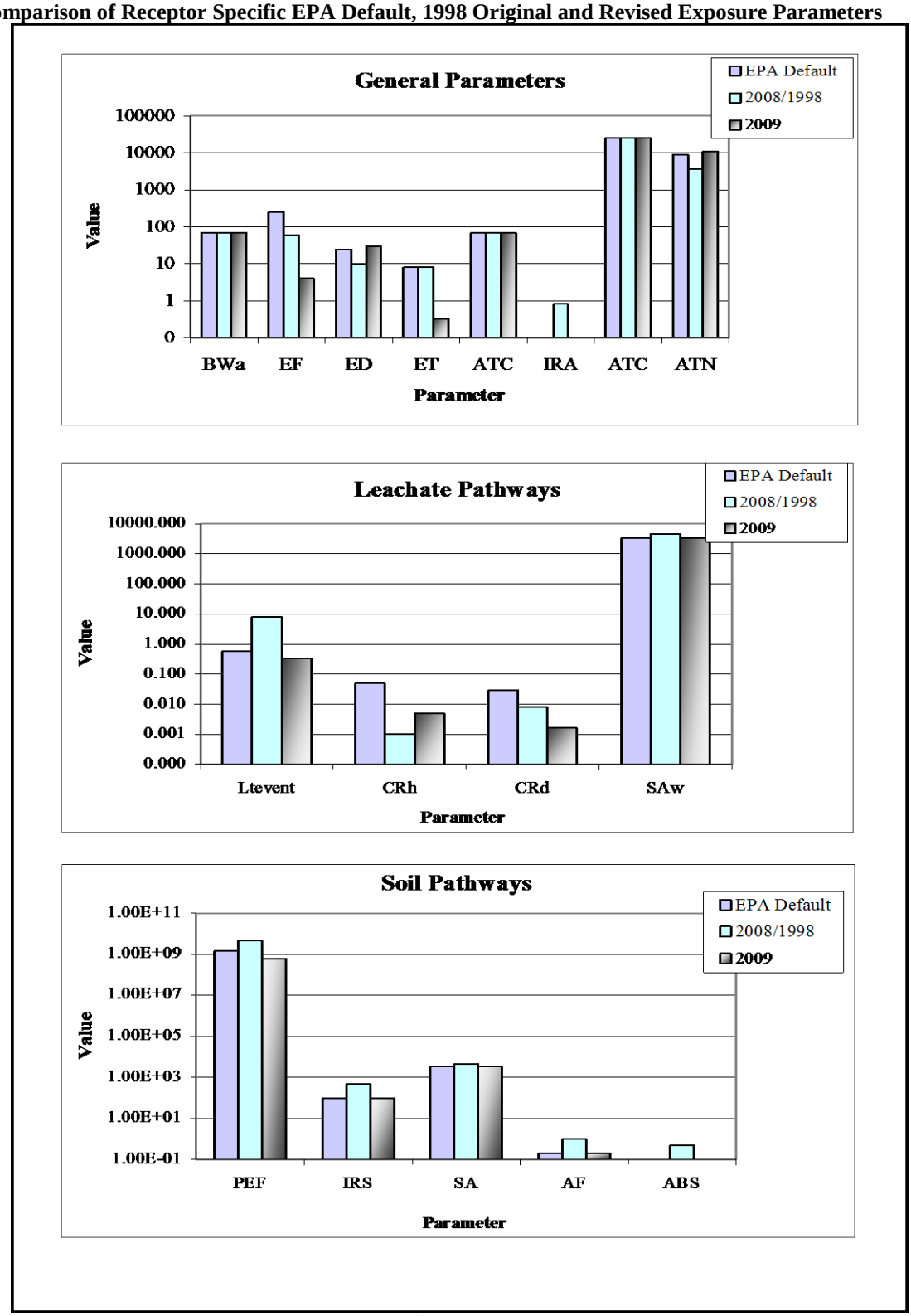
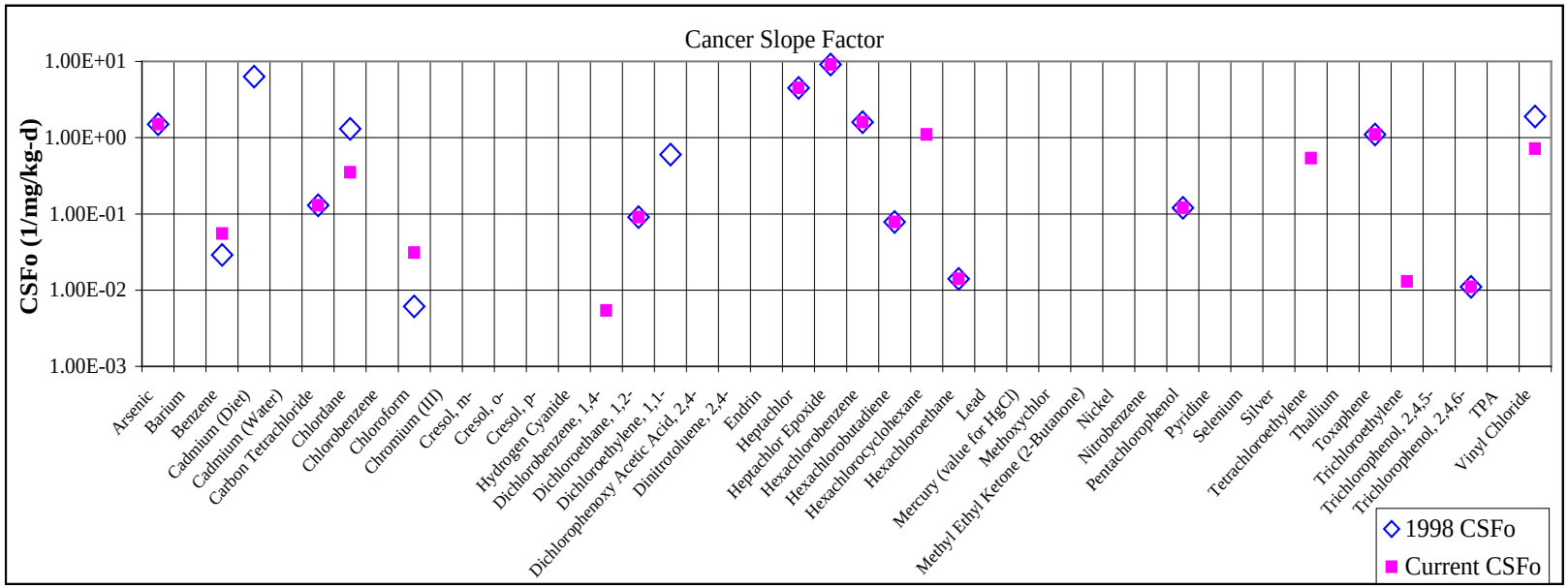


Figure 2. Comparison of Receptor Specific EPA Default, 1998 Original and Revised Exposure Parameters



Note: Values shown on a log scale due to extreme range of parameter values
See Table 2 for definitions and units
Only fixed parameters that change across categories are shown; those that vary by chemical are not presented. Those that are constant for all three categories are not shown.

Figure 3. Comparison of 1998 to Current Toxicity Values



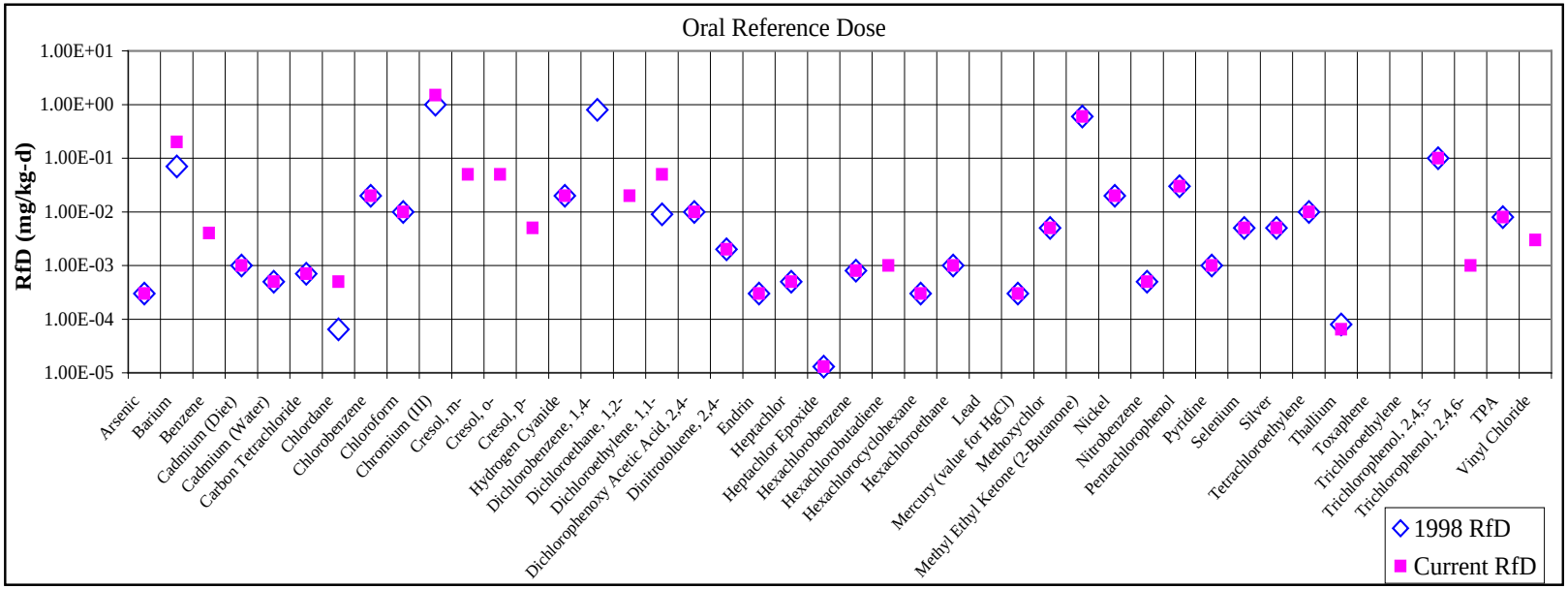


EXHIBIT D

GOLDER

TECHNICAL MEMORANDUM

DATE January 10, 2020 **Reference No.** 18111727

TO Tom Schweitzer, Waste Management

CC Joanna Moreno, Golder Associates

FROM Mark McClain, PE **EMAIL** mmcclain@golder.coim

RE: DEVELOPMENT OF DILUTION FACTORS AND TRAVEL TIMES FOR SECONDARY SUMP MONITORING PARAMETERS, DACWPF, ARAPAHOE COUNTY, COLORADO

BACKGROUND

This technical memorandum summarizes calculations of travel time and dilution factors that will be used to support alternate Action Limits for incorporation into the renewal permit for leachate parameters that are monitored in the secondary sump of the Denver - Arapahoe Chemical Water Processing Facility (DACWPF) reconstructed cell. The purpose of this analysis is to derive a basis for establishing technically defensible alternate Action Limits that are protective of human health and the environment considering the engineered liner system of the reconstructed cell and hydrogeology of the site.

This analysis provides an evaluation of the migration potential for leachate parameters to move to the first continuous groundwater zone beneath DACWPF (Lower Sandstone), the capacity of the Lower Sandstone to significantly dilute leachate parameters if they were able to reach this unit, and the migration potential for leachate parameters to move within the Lower Sandstone to a potential offsite receptor. The analysis is highly conservative because it assumes worst-case conditions. For example, the analysis presumes the geosynthetic liner is removed (i.e., assumed to not exist) to maximize downward parameter migration, and there is no implementation of corrective measures.

TECHNICAL APPROACH

A highly conservative approach (using worst-case assumptions as described below) was assumed. The technical analysis considered: migration of leachate parameters from the base of the secondary leachate collection sump through the compacted clay portion of the secondary liner system, continued downward migration through the claystone that is the primary material above the Lower Sandstone, and then migration through groundwater within Lower Sandstone downgradient to the closest designated RCRA detection monitoring well.

Worst-case assumptions summary:

1. Complete failure of the geosynthetic liner (that is, its existence is ignored)
2. Three feet (one foot of leachate and 2 ft of gravel sump) of leachate head on the clay portion of the secondary sump liner system at all times
3. No lateral spreading of leachate parameters below the bottom of secondary sump (i.e., to maximize time of travel through the underlying claystone and to minimize dilution since mixing and dispersion during migration promotes dilution)

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4. No lateral spreading in the Lower Sandstone (i.e., to minimize dilution and mixing over a larger foot print)
5. No reaction of leachate parameters with soil or soil-pore water during migration (i.e., some leachate parameters will sorb, partition, or be captured in dead-end pores).

Calculation of Dilution Factor

A steady state (long-term) dilution factor was calculated from the ratio of vertical seepage (i.e., volume of flow over time) through the clay portion of the secondary sump liner system and the underlying claystone versus the volume of groundwater flow over time through the Lower Sandstone.

- Vertical seepage was calculated as the flux through the clay portion of the secondary sump liner system and the underlying unsaturated claystone multiplied by the secondary sump bottom area, where:

Flux = 3.09×10^{-6} ft/day (see following section for calculation)

Area = 8 ft by 8 ft (from design drawings)

Flow volume over time through the clay portion of secondary sump clay liner and the underlying unsaturated claystone = flux * area = 1.98×10^{-4} ft^3/day.

- Flow volume over time through the Lower Sandstone was calculated as the flux through the saturated zone multiplied by the cross-sectional area of the Lower Sandstone underlying the bottom of the secondary sump, where:

Flux = 1.12×10^{-4} ft/day (hydraulic conductivity (K) multiplied by hydraulic gradient (i) of Lower Sandstone, where:

K = 2.85 cm/day (Golder 1989) and

i = 0.0012 (Golder 1989)

Area = 8 ft (width of secondary sump) multiplied by 40 ft (saturated thickness of Lower Sandstone)

Flow volume over time through Lower Sandstone = flux * area = 3.59×10^{-2} ft^3/day.

Dilution factor = 3.59×10^{-2} ft^3/day /1.98×10^{-4} ft^3/day = 181 (flow volume over time through Lower Sandstone divided by flow volume over time through clay portion of the secondary sump liner system and the underlying unsaturated claystone into the Lower Sandstone).

That is, parameters observed in secondary leachate collection sump would be diluted approximately 181 times before being monitored at the closest downgradient monitoring well in the Lower Sandstone.

Calculation of Flow through the Clay Portion of Secondary Sump Liner System and the Underlying Claystone

A simplified unsaturated flow model (details in Attachment A) was used to assess the flow rate through the clay portion of the secondary sump liner system and the underlying claystone. This model is derived from work presented in Bouma (1975) and Radcliffe and West (2009a) and uses the assumption that equivalent porous medium assumptions are applicable (i.e. no fractures or other preferential flow paths are present). The following parameters were used in the spreadsheet model:

Saturated hydraulic conductivity of liner = 1×10^{-7} cm/sec (maximum regulatory required hydraulic conductivity for compacted clay liner). Note that the unsaturated flow model calculates the unsaturated hydraulic conductivity based on the soil-water moisture characteristic curves, soil suction pressure, and saturated hydraulic conductivity.

Head on clay portion of secondary liner = 3 ft (one ft of leachate and 2 ft of gravel sump)

Saturated hydraulic conductivity of claystone = 1 x 10^{-9} cm/sec (Golder 1989)

Thickness of unsaturated claystone = 1,263 cm (base elevation of secondary leachate sump, 5745.6 ft, design drawings, minus groundwater elevation in closest downgradient monitoring P-113, 5704.2 ft, Golder 2018), that is 1,263 cm (41.4 feet)

Compacted clay liner retention properties were assumed to be similar to clay (Carsel and Parrish 1988)

Claystone retention properties were assumed to be similar to silty clay (Carsel and Parrish 1988), except that the porosity was updated to match that presented in Golder, 1986.

The calculated flux (flow per unit area) through the clay liner and the underlying unsaturated claystone is 3.09 x 10^{-6} ft/day (1.1 x 10^{-3} ft/yr).

Calculation of Travel Times

Travel times were calculated for seepage through the clay portion of the liner system, the underlying claystone, and groundwater within the Lower Sandstone.

For the clay portion of the secondary liner and claystone):

Flux = 3.09 x 10^{-6} ft/day (see Section 1.2)

Effective porosity = 0.1 (conservatively assumed to be equal to the saturated effective porosity, Golder 1968)

Transport velocity = flux divided by effective porosity = 3.09 x 10^{-5} ft/day

Travel time = 3,670 years (distance divided by transport velocity, where distance is 41 ft (base elevation of secondary leachate sump, 5745.6 ft, design drawings, minus groundwater elevation in closest downgradient monitoring P-113, 5704.2 ft, Golder 2018)

For the saturated zone (Lower Sandstone):

Flux = 0.0001 ft/day (hydraulic conductivity (K) multiplied by hydraulic gradient (i), where:

K = 0.09 ft/day (Golder 1989)

i = 0.0012 (Golder 1989)

Effective porosity = 0.25 (Golder 1989)

Transport velocity = flux divided by effective porosity = 0.0004 ft/day

Travel time = 760 years (distance divided by transport velocity, where distance is 125 ft horizontal distance from the secondary sump to the closest designated RCRA detection monitoring well.

In combination, the travel time from the secondary leachate sump to the nearest downgradient monitoring well is estimated to be 4,430 years.

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Chemical Waste Management, Inc. 1987. "*Amendment to the Modified Closure Plan for the Denver-Arapahoe Chemical Waste Processing Facility*," Arapahoe County, Colorado, (EPA RCRA ID #COD000695007).

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Radcliffe, D.E., and L.T. West. 2009a. Design hydraulic loading rates for on-site wastewater systems. *Vadose Zone Journal* v8: 64-74.

Radcliffe, D.E., and L.T. West. 2009b. Spreadsheet for converting saturated hydraulic conductivity to long term acceptance rate for on-site wastewater systems. *Soil Survey Horizons* v50: 20-24.

ATTACHMENT A

Unsaturated Model Details

Brief Description of Unsaturated Spreadsheet Model Used in Calculations

Flow through clay liners and unsaturated soil, with a specified leachate head on the top of the liner is essentially the same as the consideration of flux through the base of a wastewater trench; they both consider unsaturated zone flow for a situation involving a specified overlying fluid depth (equivalent to leachate depth for the current analysis), a biomat restrictive flow layer (equivalent to clay liner(s) for the current analysis), and underlying unsaturated soil or rock. A wastewater trench flux calculator (spreadsheet model) was used in the unsaturated zone seepage calculation described in the main text.

The following text describing the equations and assumptions embedded in the spreadsheet model is taken from Radcliffe and West (2009a):

"Bouma (1975) developed a simple equation for estimating steady downward flow through the bottom of an onsite wastewater system (OWS) trench:

$$K_{bs}\frac{h_0 - h_s + Z_b}{Z_b} = K(h_s)$$

where K_{bs} is the saturated hydraulic conductivity of the biomat, h_0 is the height of water ponded in the trench [L], h_s is the pressure head in the soil just beneath the biomat [L], Z_b is the thickness of the biomat [L], and $K(h_s)$ is the unsaturated hydraulic conductivity of the soil at a pressure head of h_s.

Under the conditions present in OWS trenches, the flux through the biomat is equal to the flux through the underlying soil. The term on the left-hand side of the above equation represents flux through the biomat and the term on the right-hand side represents flux through the underlying soil. Bouma (1975) used a unit hydraulic gradient below the trench bottom by assuming that the pressure head would be constant with depth for at least a short interval beneath the biomat ($dh/dz = 0$), and hence flux would be equal to the unsaturated hydraulic conductivity of the soil at the soil water pressure head just beneath the biomat (h_s) as shown in the equation above. To solve the equation under these conditions, an iterative approach or a root solver must be used to find the value of h_s that will make the fluxes (when multiplied by applicable area) on both sides of the equation equal."

This approach is coded into a spreadsheet, known as the Bouma Calculator, available at this link, documented here, and described in Radcliffe and West (2009b).

Radcliffe and West (2009a) used both HYDRUS (2D) and the Bouma Calculator to calculate fluxes through the base of trenches for a variety of soil conditions and types and compared resulting seepage rates. They concluded that: "The Bouma (1975) equation, modified to account for unsaturated conditions in the biomat, accurately predicted trench bottom fluxes in all cases except the shallow water table simulations with the silt and silt loam textural classes."

Bouma, J. 1975. Unsaturated flow during soil treatment of septic tank effluent. *J. Environ. Eng. Div. Am. Soc. Civ. Eng.* 101: 967-983.

Radcliffe, D.E., and L.T. West. 2009a. Design hydraulic loading rates for on-site wastewater systems. *Vadose Zone Journal* v8: 64-74.

Radcliffe, D.E., and L.T. West. 2009b. Spreadsheet for converting saturated hydraulic conductivity to long term acceptance rate for on-site wastewater systems. *Soil Survey Horizons* v50: 20-24.

EXHIBIT E

Risk Assessment Addendum For Perfluorooctane Sulfonate (PFOS) And Perfluorooctanoic Acid (PFOA)

December 23, 2019

Terra Technologies Environmental Services
Evergreen, Colorado

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Acronyms and Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CSF	Cancer Slope Factor
DACWPF	Denver Arapaho Chemical Waste Processing Facility
ET	Exposure Time
GIABS	Gastrointestinal Absorption Factor
HHRA	Human Health Risk Assessment
HLC	Henry's Law Constant
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk Factor
mg/kg	Milligram chemical per kilogram
PEF	Particulate Emission Factor
PFAS	Per- and polyfluoroalkyl substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
PPE	Personal Protective Equipment
RBSLs	Risk-Based Screening Levels
RfC	Inhalation Reference Concentration
RfD	Oral Reference Dose
RSLs	Regional Screening Levels
SLs	Screening Levels
THQ	Target Hazard Quotient
TR	Target Cancer Risk
USEPA	United States Environmental Protection Agency
VF	Volatilization Factor

1. INTRODUCTION

The objective of this human health risk assessment (HHRA) is to address per- and polyfluoroalkyl substances (PFAS) in leachate from the Denver Arapaho Chemical Waste Processing Facility (DACWPF) that is used for dust suppression at an adjacent landfill. The two PFAS compounds that will be analyzed at the site are perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA).

The leachate used in dust suppression is applied to temporary cover only within an inactive area of the landfill. Ultimately, additional layers of trash and cover are added which covers the soils to which leachate was applied. Only landfill workers that are actively engaged in applying the leachate potentially contact the leachate or the soils to which leachate is applied. Risk-based screening levels (RBSLs) are calculated herein for these two chemicals.

PFAS are persistent in water and soil because they are chemically stable and have low volatility in ionic form (ATSDR, 2018), however they readily leach from soil to groundwater. They are persistent in the environment and do not hydrolyze, photolyze, or biodegrade under typical environmental conditions (ATSDR 2018). Toxicological studies on animals indicate potential developmental, reproductive, and systemic effects in response to PFAS exposure (USEPA 2016 a,b,c,d). Although USEPA has health advisories for PFOA and PFOS, there is no information in the Integrated Risk Information System (IRIS) (https://www.epa.gov/iris) for PFOS or PFOA.

The screening levels for PFOA and PFOS are based on the toxicity information provided in the Health Advisory Levels (USEPA 2016a; USEPA 2016b). Exposure scenarios that are applicable to this site are used to derive screening levels.

2. METHODS

RBSLs are soil and leachate concentrations that correspond to a preset target cancer risk or noncancer risk level for a given exposure scenario. The RBSLs are designed to be compared directly to analytical data. Figure 1 shows a conceptual model for the leachate application.

Exposure pathways that were determined to be potentially complete in the absence of personal protective equipment (PPE) are shown in Table 1. This includes incidental ingestion, dermal contact, and inhalation of dusts. The soil contact equations presume that leachate is sprayed onto the soils, and that landfill workers then contact the soils. It is conservative in that there are no attenuation factors, and the equation assumes that any PFAS in the leachate transfers directly to the soil. In addition, direct ingestion and contact with leachate are considered. As discussed in Section 2.3, the PFAS are not volatile and therefore vapor inhalation pathways are not evaluated.

The risk assessment methodology used to develop the RBSLs is consistent with United States Environmental Protection Agency (USEPA) Risk Assessment Guidance (USEPA 1989), as defined but not limited to, the following USEPA risk assessment guidance:

- USEPA Risk Assessment Guidance for Superfund (RAGs) Volume I, Human Health Evaluation Manual (Part A), Interim Final, USEPA/540/1-89/002, December 1989 (USEPA 1989),
- USEPA RAGS Volume I, Human Health Evaluation Manual Part E, Supplemental Guidance for Dermal Risk Assessment, Final, USEPA/540/R/99/005, July 2004 (USEPA 2004),
- USEPA RAGS Volume I, Human Health Evaluation Manual Part F, Supplemental Guidance for Inhalation Risk Assessment, Final, USEPA-540-R-070-002, January 2009 (USEPA 2009), and

• USEPA. Mid-Atlantic Region. Regional Screening Tables. November 2019 (USEPA 2019).

The equations used to derive these RBSLs for soil were obtained from USEPA (2019) and are based on those used to derive the "Regional Screening Levels" or RSLs. They represent current practice by multiple USEPA regions. Forward risk equations utilize media concentrations, and predict risk based on exposure to a given media concentration. The RSLs, like the RBSL equations, are "backward" in that risk is fixed at a target level, and the corresponding concentration in the exposure medium (soil or leachate) is then solved for. This results in a media concentration associated with a preset or "target" level of risk. In order to evaluate the potential contribution of each pathway, the equations are solved for each exposure pathway separately prior to combining them for an overall RBSL.

2.1. SOIL EXPOSURE PATHWAYS

The approach for estimating the 2019 soil RBSLs for PFOS and PFOA is the same method as used in the 2009 Risk Assessment for Leachate (Terra Technologies Environmental Services 2009). It involves solving individual equations to obtain pathway-specific screening levels (SLs) in terms of milligram contaminant per kilogram soil (mg/kg) for the ingestion (ing), dermal (derm), and inhalation (inh) exposure pathways (Table 1). The inverse of each of the individual pathways is then summed to obtain a single soil concentration representative of all pathways. Evaluating individual exposure pathways allows identification of the most important exposure pathways and aids transparency. There are receptor-specific (Table 2) and chemical-specific (Tables 3 and 4) parameters that are used to populate these equations.

2.2. RECEPTOR-SPECIFIC EXPOSURE PARAMETERS

Receptor-specific parameters vary by receptor and include body weight, intakes, and activity estimates (Table 2). Body weight and skin surface area considered as typical for workers have increased slightly since the 2009 risk assessment. The new values will be used to be consistent with USEPA (2019). There is now a correction factor for the fraction of the work day for which exposure occurs (exposure time (ET)) of 8 hours /day * 1 day/24 hours. The adherence factor that predicts soil sticking to skin has decreased slightly to 0.12 mg/cm^2, but the 2009 value of 0.2 mg/cm^2 is used for PFAS to be consistent with the 2009 risk assessment, and also because spraying leachate might dampen skin causing a higher rate of adherence. This is more conservative than the default used by USEPA (2019).

2.3. CHEMICAL-SPECIFIC PARAMETERS

Many of the parameters and equations in the soil ingestion component of the 2019 PFAS analysis are the same as those in the 2009 memorandum (Terra 2009). In addition, many equations and parameters are the same as those used in the earlier reports (Terra 2008; Terra 1998). However, the dermal contact pathway of the 2019/2009 RBSL equation contains a chemical-specific parameter that accounts for the fraction of gastrointestinal absorption (GIABS) (Table 3), PFAS were not addressed previously, and the default value for body weight has increased from 70 kg to 80 kg.

In addition, the toxicity values CSFi or RfCi are not used in the 2019/2009 calculations but are replaced with the inhalation unit risk (IUR) or reference concentration (RfC) that are applied to the inhalation component of the overall 2019/2009 RBSL. These changes result in removal of body weight (BW) from the numerator of the inhalation equations, which also is different from the 2008/1998 version of the equations. In addition, the parameter for inhalation rate was removed from the 2019/2009 RBSL denominator as the equations are now based on air concentration, and not dose.

The chemical-specific parameters include the toxicity values (Table 3) and parameters that influence fate and transport (Table 4). The toxicity parameters are reported in Table 3, and described in more detail in Section 2.3.

The inhalation component of the 2019/2009 RBSL now contains a parameter to estimate volatilization from soils (VFs), but this is not applicable to PFAS since they are not volatile, as explained below.
The amount of chemical entering air in a vapor state due to volatilization from soil is estimated with the volatilization factor for soil (VFs). VF is only calculated for volatile compounds, which are defined by USEPA (2019) as:

- chemicals with a Henry's Law constant (HLC) greater than 1 x 10^{-5} atm-m^3/mole or
- a vapor pressure greater than 1 mm Hg.

The vapor pressure of PFOA and PFOS is 0.525 and 0.002 mm Hg at 25ºC, respectively (USEPA 2017). This source states that HLC for the PFAS is not measurable; however USEPA (2019) provides a HLC of 4x10^{-6} atm/m^3-mol, and ATSDR (2018) provides one of 0.362 Pa/m^3-mol, which converts to 3.57x10^{-6} atm/m^3-mol for standard units. The VF is considered to be negligible for these PFAS, which are not expected to volatilize and therefore an RBSL for volatilization is not calculated by USEPA (2019) or in this report.

2.4. SITE-SPECIFIC EXPOSURE PARAMETERS

These are parameters that are consistent across all chemicals and are specific to the site and its conditions. The only site-specific parameter is the particulate emission factor (PEF), which is amount of soil that enters the air as fugitive dust resulting in exposure due to soil inhalation. This parameter also can vary by receptor depending on activity level, and is reported in Table 2. The PEF was obtained from EPA (2019) based on soil and climatic conditions for Denver, CO.

2.5. SOIL EXPOSURE PATHWAY EQUATIONS

To estimate cancer and noncancer risk for soil exposure, the following equations for a landfill worker are used which are consistent with equations for an outdoor worker from EPA (2019):

Equation 1. Landfill Worker, Cancer Risk, Soil Ingestion

$$SLing = \frac{TR \times BWa \times ATc}{EF \times ED \times CSFo \times IRS \times 10^{-6}\ kg/mg}$$

Equation 2. Landfill Worker, Cancer Risk, Soil Dermal Contact

$$SLderm = \frac{TR \times BWa \times ATc}{EF \times ED \times \frac{CSFo}{GIABS} \times SA \times AF \times ABS \times 10^{-6}\ kg/mg}$$

Equation 3. Landfill Worker, Cancer Risk, Soil Inhalation

$$SLinh = \frac{TR \times ATc}{EF \times ED \times ET \times \frac{1\,day}{24\,h} \times IUR \times 1000\,ug/mg \times \left[\frac{1}{VFs} + \frac{1}{PEF}\right]}$$

Equation 4 . Landfill Worker, Noncancer Risk, Soil Ingestion

$$SLing = \frac{THQ \times BWa \times ATnc}{EF \times ED \times \frac{1}{RfDo} \times IRS \times 10^{-6}\ kg/mg}$$

Equation 5. Landfill Worker, Noncancer Risk, Soil Dermal Contact

$$SLderm = \frac{THQ \times BWa \times ATnc}{EF \times ED \times \frac{1}{RfDo \times GIABS} \times SA \times AF \times ABS \times 10^{-6}\ kg/mg}$$

Equation 6. Landfill Worker, Noncancer Risk, Soil Inhalation

$$SLinh = \frac{THQ \times ATnc}{EF \times ED \times ET \times \frac{1\,day}{24\,h} \times \frac{1}{RfC} \times \left[\frac{1}{VFs} + \frac{1}{PEF}\right]}$$

The total cancer or noncancer soil screening level or soil RBSL for all soil-based pathways combined is calculated from the results of Equations 1, 2, and 3 for cancer; and 4, 5, and 6 for noncancer. For soil, the total RBSL is as follows:

Equation 7 – Total Soil RBSL as Expressed by Summation of Exposure Pathways

$$RBSL_{soil}(mg/kg) = \frac{1}{\frac{1}{SLing} + \frac{1}{SLderm} + \frac{1}{SLinh}}$$

2.6. LEACHATE EXPOSURE PATHWAY EQUATIONS

There are three potentially complete exposure pathways associated with leachate exposure by workers. These are direct ingestion, dermal contact, and inhalation of volatiles emanating from the spray as it is applied. The PFAS are not volatile, and thus there is no potential exposure from volatilization. The absence of an RfC or IUR also precludes quantification of the inhalation pathway from volatilization even if an air concentration were estimated.

The equation used for ingestion of leachate resembles that for tap water; however, the incidental ingestion rate of leachate is lower than drinking water ingestion or incidental ingestion during swimming. It was assumed that at most workers would ingest 5 ml (1 teaspoon) of leachate per hour for a 20 minute duration of leachate application. Thus, the exposure equations are:

Equation 8 – Cancer Risk, Leachate Ingestion

$$SLing\ (\frac{ug}{L}) = \frac{TR \times BWa \times ATc \times 1000\ ug/mg}{EF\ \times ED\ \times CSF_o \times\ CR_d}$$

Equation 9 – Noncancer Risk, Leachate Ingestion

$$SLing\ (\frac{ug}{L}) = \frac{THQ \times BWa \times ATnc \times 1000\ ug/mg}{EF\ \times ED\ \times \frac{1}{RfD_o} \times\ CR_d}$$

The parameters are defined in Tables 2, 3, and 4.

The current approach used in this analysis for addressing dermal uptake is consistent with RAGS E (EPA, 2004). The approach for evaluating dermal uptake from liquids differs from solids, and involves estimating a dose absorbed from liquid across the dermal membrane into the body. The dermally absorbed dose (DAD) for organics from liquids depends on exposure time and the absorbed dose per event (DA_{event}) (EPA, 2004). Therefore, solving for the screening levels or liquid concentration is written consistent with EPA (2019):

Equation 10 –Equation for Estimating Dermal Absorbed Dose from Leachate

$$If\ ET\ \left(\frac{h}{ev}\right) \leq t^{*}(h)\ \ then$$

$$SL_{derm}\left(\frac{ug}{L}\right) = \frac{DA_{event}\left(\frac{\mu g}{cm^2 - ev}\right) \times 1000\ \frac{cm^3}{L}}{2\ \times FA\ \times Kp\ (\frac{cm}{h})\frac{\sqrt{6\ \times\ \tau_{\ event}(\frac{h}{ev}) \times ET(\frac{h}{ev})}}{\pi}}$$

$$If\ ET\ \left(\frac{h}{ev}\right) > t^{*}(h)\ \ then$$

$$SL_{derm}\left(\frac{ug}{L}\right) = \frac{DA_{event}\left(\frac{\mu g}{cm^2 - ev}\right) \times 1000\ \frac{cm^3}{L}}{FA\ \times Kp\ \left(\frac{cm}{h}\right) \times \left[\frac{ET\ \left(\frac{h}{ev}\right)}{1+B} + 2 \times \tau_{\ event}\left(\frac{h}{ev}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where for cancer-based health effects, DA_{event} is calculated as:

Equation 11 – Equation for DA_{event} for Cancer-Based Health Effects

$$\boldsymbol{DA_{event}\ \left(\frac{\mu g}{cm^2 - ev}\right) = \frac{THQ\ \times ATc\ (25550\ d) \times\ BW\ (kg) \times\ 1000\frac{ug}{mg}}{\frac{CSFo}{GIABS} \times\ EV\ \left(\frac{ev}{d}\right) \times\ ED\ (y) \times EF\left(\frac{d}{y}\right) \times SA(cm^2)}}$$

And where for noncancer-based health effects, DA_{event} is calculated as:

Equation 12 – Equation for DA_{event} for Noncancer-Based Health Effects

$$DA_{event}\ \left(\frac{\mu g}{cm^2 - ev}\right) = \frac{\text{THQ}\ \times \text{ATnc (ED y} * 365\ \frac{\text{d}}{y}) \times\ \text{BW (kg)} \times\ 1000\frac{ug}{mg}}{\frac{1}{RfD\ (\frac{mg}{kg-d}) \times GIABS} \times\ EV\ \left(\frac{ev}{d}\right) \times\ ED\ (y) \times EF\left(\frac{d}{y}\right) \times SA(cm^2)}$$

The total leachate RBSL for all direct contact leachate-based pathways combined is calculated from the results of Equations 8, 10, and 11 for cancer and 9, 10, and 12 for noncancer, respectively. Summing the inverse of the results of the individual exposure pathways yields:

Equation 13 – Total Leachate RBSL as Expressed by Summation of Exposure Pathways

$$RBSL\ \left(\frac{ug}{L}\right) = \frac{1}{\frac{1}{SLing} + \frac{1}{SLderm}}$$

2.7. RBSL FOR COMBINED MEDIA

In order to establish an RBSL protective of all of the soil and leachate pathways, the RBLSs derived for each medium must be combined. The leachate RBSLs must be converted from ug/L to mg/L. In addition, the volume of leachate applied to a given area of soil must be factored in. The equation used to combine the soil and leachate RBSLs can be visualized as follows:

Equation 14 – RBSL Inclusive of All Exposure Pathways

$$RBSL_{all}\ (mg/L) = \frac{1}{\frac{1}{RBSL_{soil}} + \frac{1}{RBSL_{leachate}}}$$

However, the RBSLs for soil and leachate cannot be additively combined as they are in terms of different units. The concentrations in soil are themselves dependent on the leachate concentration (Figure 1). A soil concentration can be linked to the leachate concentration as follows, conservatively assuming there is 100% efficiency in cross-media transfer:

Equation 15 – Relationship of Soil Concentrations to Applied Leachate Concentrations

$$Csoil = CL * VL * \frac{1}{Ms}$$

Where:
Csoil = Soil concentration (mg/kg)
CL = Leachate concentration (mg/L)
VL = Volume of leachate applied (13,626 L/ac)
Ms = Mass of soil per acre (803,116 kg/ac)

Equation 15 can therefore be rewritten as follows to solve for a leachate RBSL (i.e., the allowable leachate concentration) given all the potential exposure pathways. Note that these RBSLs conservatively assume that there is no PPE and that the exposure pathways are complete. Equation 16 is the equation for the leachate RBSL considering cumulative exposure across all soil and leachate pathways:

Equation 16 – RBSL Inclusive of All Exposure Pathways and Media

$$RBSL_{all}\ (mg/L) = \frac{1}{\frac{1}{\frac{RBSL_{soil} \times Ms}{VL}} + \frac{1}{RBSL_{leachate}}}$$

Where:
$RBSL_{all}$ = the allowable leachate concentration (mg/L) without PPE

3. TOXICITY PROFILES FOR PFAS

3.1. PFAS NONCARCINOGENIC TOXICITY VALUES

USEPA derived an RfD for PFOS of 0.00002 mg/kg-day (USEPA 2016c). The toxicity endpoint for this RfD is decreased neonatal rat body weight from a two-generation study. An uncertainty factor of 30 was applied to this RfD, which included an uncertainty factor of 10 for intrahuman variability and an uncertainty factor of 3 for interspecific variability between humans and animals. The USEPA (2016a) issued a lifetime drinking water health advisory for PFOS of 0.07 ug/L based on this RfD derived from the rat study. The lifetime health advisory is considered protective of adverse effects in adults for kidney and liver toxicity, and protective of the general population (USEPA 2016a).

The RfD for PFOA is the same as PFOS, although it is derived from a mouse instead of a rat study. The PFOA RfD of 0.00002 mg/kg/day is based on developmental toxicity effects in mice (USEPA 2016d), specifically reduced ossification and accelerated puberty (in males). The total uncertainty factor is 300, and includes a factor of 10 for intrahuman variability, a factor of 3 to account for differences between animals and humans, and a factor of 10 to account for use of a lowest observed adverse effect level (LOAEL) instead of a no observed adverse effect level (NOAEL).

There is no inhalation toxicity value (RfC) for either PFOS or PFOA (USEPA 2016 a,b,c). Therefore, evaluation of noncancer health effects due to inhalation cannot be performed.

3.2. PFAS CARCINOGENIC TOXICITY VALUES

The toxicity value used to predict carcinogenic risk for dermal and ingestion exposure to water or soils is the oral cancer slope factor (CSF). The CSF converts estimated daily intakes averaged over a lifetime of exposure to an incremental risk of an individual developing cancer. The CSF is expressed in units of the inverse of milligrams chemical per kilogram body weight per day (i.e., 1/mg/kg-d or $mg/kg\text{-}d)^{-1}$).

The inhalation unit risk (IUR) factor is used to predict carcinogenic risk for inhalation exposure for fugitive dust or vapor emissions from bulk solid media, as well as risk due to inhalation of air. The units for the IUR are the inverse of micrograms chemical per cubic meter of air, or $1/ug/m^3$, or $(ug/m^3)^{-1}$. The toxicity values for evaluating cancer risk for PFAS are summarized in Table 4.

USEPA (2016c) stated that there is "suggestive evidence" of carcinogenicity for PFOS based on liver, thyroid, and mammary fibroadenomas identified in rats. This evidence is not considered strong because a linear dose-response was not observed for thyroid or mammary fibroadenomas. The liver tumor effect occurred only in the high-dose males and females, and only one hepatocellular carcinoma was observed. In addition, the genotoxicity data were negative, and human epidemiology studies could not correlate exposure with cancer incidence (USEPA 2016c). The USEPA health advisory documents (USEPA 2016a,b,c) judged the available information at that time to be too limited to derive a quantitative cancer assessment. The same CSF was applied to PFOS. This is likely overly conservative since USEPA (2016c) did not define quantitative numeric cancer toxicity values for PFOS. The CSF originates from the Drinking Water Support Document for the Health Advisory (DWSHA) for PFOA (USEPA 2016d). According to USEPA (2016d), the CSF is based on human epidemiology evidence indicating an association of serum PFOA with kidney and testicular tumors. In addition, two chronic PFOA bioassays support its ability to be tumorigenic in rats, including liver, testes, and pancreas. USEPA estimated a CSF of 0.07 $(mg/kg/day)^{-1}$ based on testicular tumors (USEPA 2016d).

There is no IUR toxicity value for either PFOS or PFOA. Therefore, evaluation of cancer health effects due to inhalation cannot be performed.

4. RISK-BASED SCREENING LEVEL FOR LEACHATE (RBSLS)

The USEPA calculator outdoor worker scenario was used to calculate the RBSLs for soil using the exposure parameters shown in Table 2. The recreational visitor scenario was used to calculate the RBSLs for exposure to leachate by zeroing all juvenile parameters, and using the site-specific values from Table 2. The RBSLs are based on a target hazard quotient (THQ) of 1, or a target cancer risk (TR) of $1x10^{-6}$.

The RBSLs for the soil exposure pathways are shown in Table 5. A carcinogenic RBSL was only calculated for PFOA. It was assumed for this analysis that PFOS also could produce cancer effects, and so the soil RBSL would be the same for either compound. The noncancer health effects are the more conservative screening levels (SLs). Therefore, the soil RBSL for both compounds is based on the noncancer toxicity values.

The RBSLs for the leachate exposure pathways (Table 6) are only quantified for direct ingestion. Parameters required for quantifying the dermal exposure pathway such as Kp and other chemical-specific values are not available at this time. The noncancer health effects are the more conservative SLs. Therefore, the leachate RBSL for both compounds is based on the noncancer toxicity values.

Based on the assumptions used in the risk analysis, the RBSL for each chemical for soil and leachate exposure combined for both PFOS and PFOA is 88.3 mg/L (i.e., the RBSL for PFOS is 88.3 mg/L, and the RBSL for PFOA is 88.3 mg/L) (Table 7). This is for contact with both soil and leachate to either chemical individually. The cumulative or summed measured concentration of both PFAS should also not exceed 88.3 mg/L because the health effects could be additive. Exposure to concentrations at or below this level is not expected to result in adverse health effects.

5. UNCERTAINTY ANALYSIS

All risk assessments contain uncertainties. The purpose of the uncertainty analysis is not to remove these uncertainties, but to identify them and predict their effect on the risk assessment results.

There are typical uncertainties that are associated with the underlying toxicity data, which are often extrapolated from animal studies and contain uncertainty factors due to database adequacy. There is uncertainty in the toxicity values for the PFAS. There are no CSF values for PFOS, and so it was assumed that the toxicity would be similar. This assumption does not affect the results of the risk assessment since the noncancer health effects are more protective. There are no toxicity values (i.e., RfC or IUR) for evaluation and quantification of inhalation of fugitive dust toxicity, which could bias the risk results low since this pathway is not quantified.

There are uncertainties associated with the chemical parameters and the exposure pathways. Dermal contact pathways for direct contact with leachate cannot be quantified at this time due to lack of Kp and other parameters required for the dermal pathway evaluation. This could potentially bias the risk results low. However, workers at the site wear PPE to prevent dermal contact with the leachate. This PPE eliminates dermal exposure and therefore dermal risk, ultimately meaning that risk estimates are not biased low from lack of dermal exposure parameters.

There are also uncertainties because of the receptor parameters as well. In general, the conservative exposure parameters applied are expected to represent any potentially exposed workers. It is assumed that a worker would apply leachate for 30 years, which would tend to bias the risk results high.

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TABLES

Table 1. Potentially Complete Exposure Pathways Evaluated as a Component of the RBSLs	
Medium	Industrial Land Use
Leachate	Incidental Ingestion Dermal absorption Inhalation of volatiles emanating from spray[1]
Soil	Incidental Ingestion Inhalation of particulates Inhalation of volatiles emanating from soil[1] Dermal absorption

Notes:
[1] – This pathway is recognized to exist, but is not applicable to the PFAS evaluation because of their low volatility

Table 2. Receptor-Specific Exposure Parameters Used in the RBSL Equations						
Exposure Type	**Parameter Name and Units**	**Abbreviation**	**EPA Default Worker**	**2008/1998 Industrial Worker**	**2009 Site-Specific Industrial Worker**	**2019 Site-Specific Industrial Worker**
General	Adult Body Weight (kg)	BWa	80[a]	70	70	80[a]
	Exposure Frequency (d/yr)	EF	250	60	4	4
	Exposure Duration-Adult (yr)	ED	25	10	30	30
	Exposure Time (hr/d)	ET	8	8	0.33	0.33
	Number of Events Daily (unitless)	EV	1	1	1	1
	Averaging Time - Cancer (days)	ATc	25550	25550	25550	25550
	Averaging Time Adult - Noncancer (ED*365) (days)	ATnc	9125	3650	3650	3650
	Target Hazard Quotient (unitless)	THQ	1	1	1	1
	Target Risk (unitless)	TR	1.00E-06	1.00E-06	1.00E-06	1.00E-06
Leachate and Soil Ingestion, Dermal Contact, and Inhalation Parameters	Event Time (hr)	t_{event}	0.58	8	0.33	0.33
	Fraction Absorbed	FA	Varies	Varies	Varies	Varies
	Hourly Incidental Leachate Ingestion Rate (L/h)	CR_h	0.05[b]	0.001	0.005	0.005
	Daily Incidental Leachate Ingestion Rate (L/d)	CR_d	0.4[b]	NA	0.0017	0.0017
	Surface Area - Adult (cm^2)	SAw	3527[c]	4700	3300	3527[c]
	Dermal Permeability Constant	(K_P)	Varies	Varies	Varies	Varies
	Particulate Emission Factor (m^3/kg)	PEF	1.36E+09	4.63E+09	6.1E+08[d]	7.55E+09[d]
	Volatilization Factor (m^3/kg)	VFs	Varies	Varies	Varies	NA
	Soil Ingestion Rate - Adults (mg/d)	IRS	100	480	100	100
	Surface Area - Adult (cm^2/d)[c]	SA	3527[c]	4700	3300	3527[c]
	Adherence Factor - Adult (mg/cm^2)	AF	0.12[e]	1	0.2	0.2[e]
	Inhalation Rate - Adult (m^3/h)	IRA	NA	0.83	NA	NA

Notes:
NA – Not applicable
USEPA values are from USEPA (2019) Outdoor Worker unless otherwise noted below:

a. Default body weight has increased from 70 kg to 80 kg
b. A standard parameter is lacking. Value shown based on incidental ingestion during swimming is 50 ml/hr as a default (EPA, 1989) * 8 hr/d. A current site value of 5 ml/hr (1 teaspoon) for the 18 minute exposure (rounded up to 20 minutes or 0.33 hr) is shown.
c. Surface area has increased from 3300 to 3527 cm^2 as a default for workers in USEPA (2019) RSL Calculator
d. As calculated for Denver CO, 10 acre site with RSL calculator (USEPA 2019)
e. The adherence factor default is 0.12 mg/cm^2 for outdoor workers. More conservative value used for site-workers consistent with 2009 values, and because adherence may be higher at site.

Table 3. Chemical-Specific Toxicity Values and Adjustment Factors							
Analyte	**Cancer Slope Factor (CSFo) ($(mg/kg\text{-}day)^{-1}$)**	**Inhalation Unit Risk (IUR) ($(ug/m^3)^{-1}$)**	**Oral Reference Dose (RfD) (mg/kg-day)**	**Inhalation Reference Concentration (RfC) (mg/m^3)**	**Dermal Absorption Fraction for Soil (ABS) (unitless)**	**Relative Bioavailability Factor (RBA) (unitless)**	**Gastrointestinal Absorption Factor (GIABS) (unitless)**
Perfluorooctane sulfonic acid (PFOS)	-	-	2E-05	-	0.1	1	1
Perfluorooctanoic acid (PFOA)	7.00E-02	-	2E-05	-	0.1	1	1

Notes: Toxicity values obtained from Drinking Water Health Advisories (USEPA 2016 a,b,c,d)

Table 4. Chemical-Specific Parameters Used in Exposure Equations										
Analyte Name	**Henry's Law Constant (HLC) (atm/m^3-mol)**	**Diffusivity in Air (D_{ia}) (cm^2/s)**	**Diffusivity in Water (D_{iw}) (cm^2/s)**	**Soil-Water Partition Coefficient (K_{oc}) (cm^3/g)**	**Solubility (S) (mg/L)**	**Apparent Diffusivity (D_A) (cm^2/s)**	**VFs (m^3/kg)**	**Dermal Permeability Constant (Kp) (cm/h)**	**Time To Steady State (t*) (hr)**	**Lag Time Per Event (τ_{event}) (hr/event)**
Perfluorooctane sulfonic acid (PFOS)	NV	2.07E-02	5.25E-06	3.72E+02	6.80E+02	NA	NA	NV	NV	NV
Perfluorooctanoic acid (PFOA)	4.00E-06	2.26E-02	5.79E-06	1.15E+02	9.50E+03	NA	NA	NV	NV	NV

Notes:
NA – Not applicable; NV – No value available
atm/m^3-mol – atmospheres per cubic meter per mole
cm^3/cm^3 – unitless HLC or cubic centimeter per cubic centimeter
cm^2/s – centimeter squared per second
cm^3/g –cubic centimeter per gram
mg/L – milligram per liter
m^3/kg – cubic meter per kilogram
cm/h – centimeter per hour

Table 5. RBSLs for the Soil Contact Pathways									
Chemical	**Cancer Ingestion SL (mg/kg)**	**Cancer Dermal SL (mg/kg)**	**Cancer Inhalation SL (mg/kg)**	**Carcinogenic SL (mg/kg)**	**Noncancer Ingestion SL (mg/kg)**	**Noncancer Dermal SL (mg/kg)**	**Noncancer Inhalation SL (mg/kg)**	**Noncarcinogenic SL (mg/kg)**	**Soil RBSL (mg/kg)**
Perfluorooctane sulfonic acid (PFOS)	-	-	-	Assume same SL as PFOA	1.46E+03	2.07E+03	-	8.56E+02	8.56E+02 nc
Perfluorooctanoic acid (PFOA)	2.43E+03	3.45E+03	-	1.43E+03	1.46E+03	2.07E+03	-	8.56E+02	8.56E+02 nc

Notes: nc – RBSL based on noncancer endpoints

Table 6. RBSLs for the Leachate Contact Pathways							
Chemical	**Cancer Ingestion SL (mg/L)**	**Cancer Dermal SL (mg/L)**	**Carcinogenic SL (mg/L)**	**Noncancer Ingestion SL (mg/L)**	**Noncancer Dermal SL (Adult) (mg/L)**	**Noncarcinogenic SL (Adult) (mg/L)**	**Leachate RBSL (mg/L)**
Perfluorooctane sulfonic acid (PFOS)	-	-	-	8.85E+01	-	8.85E+01	8.85E+01 nc
Perfluorooctanoic acid (PFOA)	1.83E+02	-	1.83E+02	8.85E+01	-	8.85E+01	8.85E+01 nc

Notes: nc – RBSL based on noncancer endpoints

Table 7. RBSLs for PFAS							
Chemical	**CAS Number**	**2019 RBSLsoil (mg/kg)**		**2019 RBSLLeachate (mg/L)**		**2019 RBSLall (mg/L)**	
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	8.56E+02	nc	8.85E+01	nc	8.83E+01	nc
Perfluorooctanoic acid (PFOA)	335-67-1	8.56E+02	nc	8.85E+01	nc	8.83E+01	nc

Notes: nc – RBSL based on noncancer endpoints

FIGURES

Figure 1. Conceptual Site Model for Development of Risk Based Screening Levels (RBSLs)

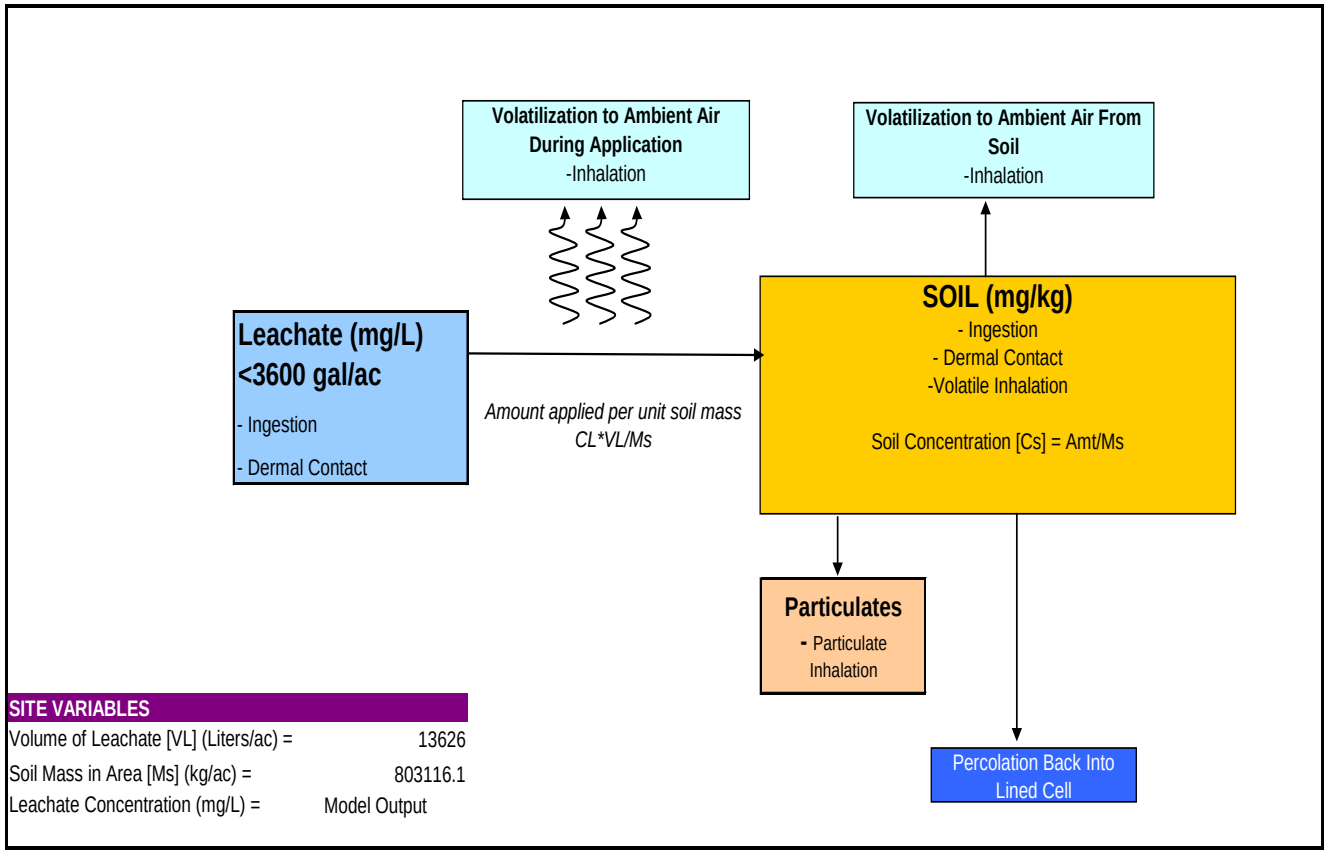

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EXHIBIT F

GOLDER

TECHNICAL MEMORANDUM

DATE January 10, 2020 **Reference No.** 18111727

TO Tom Schweitzer, Waste Management

CC Joanna Moreno, Golder Associates

FROM Mark McClain, PE **EMAIL MMcClain@golder.com**

RE: RECOMMENDATIONS FOR MONITORING WELLS FOR DACWPF

BACKGROUND

The draft renewal for the DACWPF permit triggers action if leachate within the secondary sump of the reconstructed cell (Cell) exhibits a confirmed detection of any parameter listed in Table G-1. In the event a parameter in the secondary sump exceeds its Action Limit, existing permit conditions require additional monitoring wells to be installed in the Upper and Intermediate Sandstone units for sampling and analysis (see attached general location map, Figure 3 of draft permit, note figures have been modified to include location of sump and other minor details in this memo). After careful review of the hydrogeologic regime associated with the DACWPF cell including evaluation of groundwater level data collected from existing monitoring wells since the completion of closure of the Cell in 1990 and the lateral and vertical extent of the Upper and Intermediate Sandstone units adjacent to and beneath the Cell, site hydrogeologic conditions indicate that even if groundwater could be collected from the Upper and Intermediate Sandstone units the resultant data would not be meaningful for assessing a potential leachate release from the secondary sump.

DISCUSSION

The site hydrogeology demonstrates that the existing Lower Sandstone wells are best positioned for monitoring a potential leachate release from the DACWPF secondary sump to ensure protection of human health and the environment. The rationale for this position is provided below:

1) The hydrogeologic conditions beneath DACWPF demonstrate that existing and possible future wells completed in the Upper and Intermediate Sandstones cannot realistically intercept a potential leachate release from the secondary sump because:

   - The Upper Sandstone wells (proposed and existing) are/would be at an elevation above the elevation of the bottom of the secondary sump because this unit occurs close to the ground surface (see attached Figures 6 and 12 of draft permit); therefore, any wells completed in this unit cannot intercept a leachate release from the secondary sump; and
   - The Intermediate Sandstone is generally a low permeability, laterally discontinuous unit located below the Upper Sandstone (see attached Figures 7 and 12 of draft permit); although it contains small, intermittent more permeable zones that contain water, the only identified saturated zone within the

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Intermediate Sandstone beneath DACWPF occurs in a very limited area along the southern cell boundary based on past site characterization activities (i.e., borings and piezometer installations GC-16, GC-22, and GC-26 - see attached Figure 7 from the draft permit). Therefore, the possibility for a leachate release from the secondary sump to reach groundwater within this saturated portion of the Intermediate Sandstone and manifest itself to become an environmental concern is remote. Thus, proposed wells within this unit are impractical as they are not effectively positioned to detect a leachate release from the secondary sump.

2) Based on the above, a leachate release from the secondary sump would be most readily detected in the Lower Sandstone wells. If a release from the secondary sump were to occur, analytes would slowly migrate vertically downward through primarily unsaturated clay material and into the Lower Sandstone (see attached Figures 8 and 12 of draft permit). Any release would take a significant amount of time to move through this material especially considering leachate within the secondary sump is routinely pumped out and there would not be a consistent driving head to promote vertical migration. Nevertheless, if analytes were able to migrate to groundwater within the Lower Sandstone unit, analytes would then migrate laterally to the hydraulically downgradient Lower Sandstone wells P-113, P-114 and P-115. As concluded in previous hydrogeologic investigations, these wells are suitably located to detect a potential leachate release from the secondary sump while providing early detection and environmental protection to any downgradient receptors.

3) Evaluation of the lateral gradients and hydraulic conductivity within the Lower Sandstone indicates that the groundwater is moving very slowly in this unit, on the order of only 0.16 feet per year (i.e., 1.6 feet every 10 years). At this rate, there would be ample time to address any analytes that may be a concern prior to affected groundwater potentially migrating offsite toward possible receptors since the DACWPF property line is over 100 feet downgradient of the monitoring wells.

RECOMMENDATION

Given the data that has been collected over the years and the hydrogeologic conditions described above, focusing on monitoring only the Lower Sandstone provides an appropriate and effective monitoring approach and should be incorporated into the renewal permit. Monitoring only the Lower Sandstone is protective of human health and the environment and represents the best action if confirmed Action Limits are exceeded for any parameter listed in Table G-1.

MEM/ds

https://golderassociates.sharepoint.com/sites/34960g/deliverables/techmemos/tm-discussionofmonitoringwellsdacwpf_09jan20/18111727 tm_discussionofmonitoringwells-dacwpf_10jan20.docx

Figures

LEGEND

- 5780 — 2019 CONTOURS
- ROADS
- PROPERTY BOUNDARY
- P-107 GC-18 — EXISTING GROUNDWATER MONITORING NETWORK
- I-1 — UPPER AND INTERMEDIATE SANDSTONE WELLS TO BE INSTALLED IF NECESSARY
- BM-1A — BENCHMARK LOCATIONS

NOTE(S)

1. CONTOURS FROM AERIAL PHOTOGRAPHY TAKEN ON JANUARY 8, 2019 FOR WASTE MANAGEMENT.

0 100 200
1" = 200' FEET

CLIENT
WASTE MANAGEMENT OF COLORADO, INC.

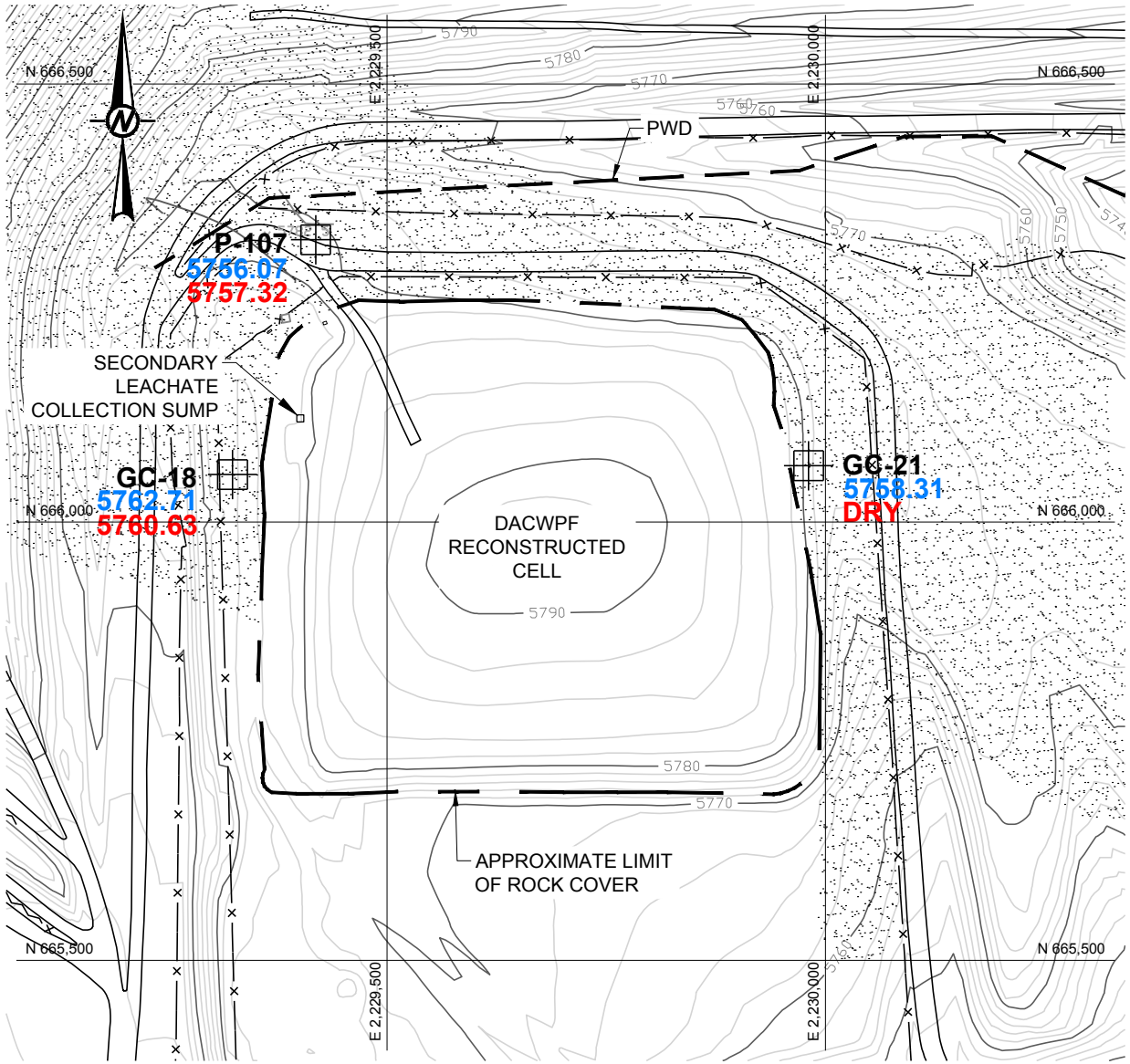
CONSULTANT
GOLDER

YYYY-MM-DD	2019-02-27
DESIGNED	RM
PREPARED	DBS
REVIEWED	MEM
APPROVED	RM

PROJECT
DACWPF RECONSTRUCTED CELL FACILITY
PART B POST-CLOSURE PERMIT RENEWAL

TITLE
FACILITY MAP

PROJECT NO. 18111727 REV. A



LEGEND

- PIEZOMETER
- PERCHED WATER DRAIN (PWD)
- APPROXIMATE EXTENT OF SILTY SANDSTONE (SM) IN UPPER SANDSTONE UNIT

NOTE(S)

1. WATER LEVELS SHOWN IN *BLUE* MEASURED ON 05/09/2018.
2. WATER LEVELS SHOWN IN *RED* MEASURED ON 10/31/2018.
3. ELEVATION GIVEN IN FEET ABOVE MEAN SEA LEVEL.

0 100 200
1" = 200' FEET

CLIENT
WASTE MANAGEMENT OF COLORADO, INC.

PROJECT
DACWPF RECONSTRUCTED CELL FACILITY
PART B POST-CLOSURE PERMIT RENEWAL

CONSULTANT
GOLDER

YYYY-MM-DD	2019-02-27
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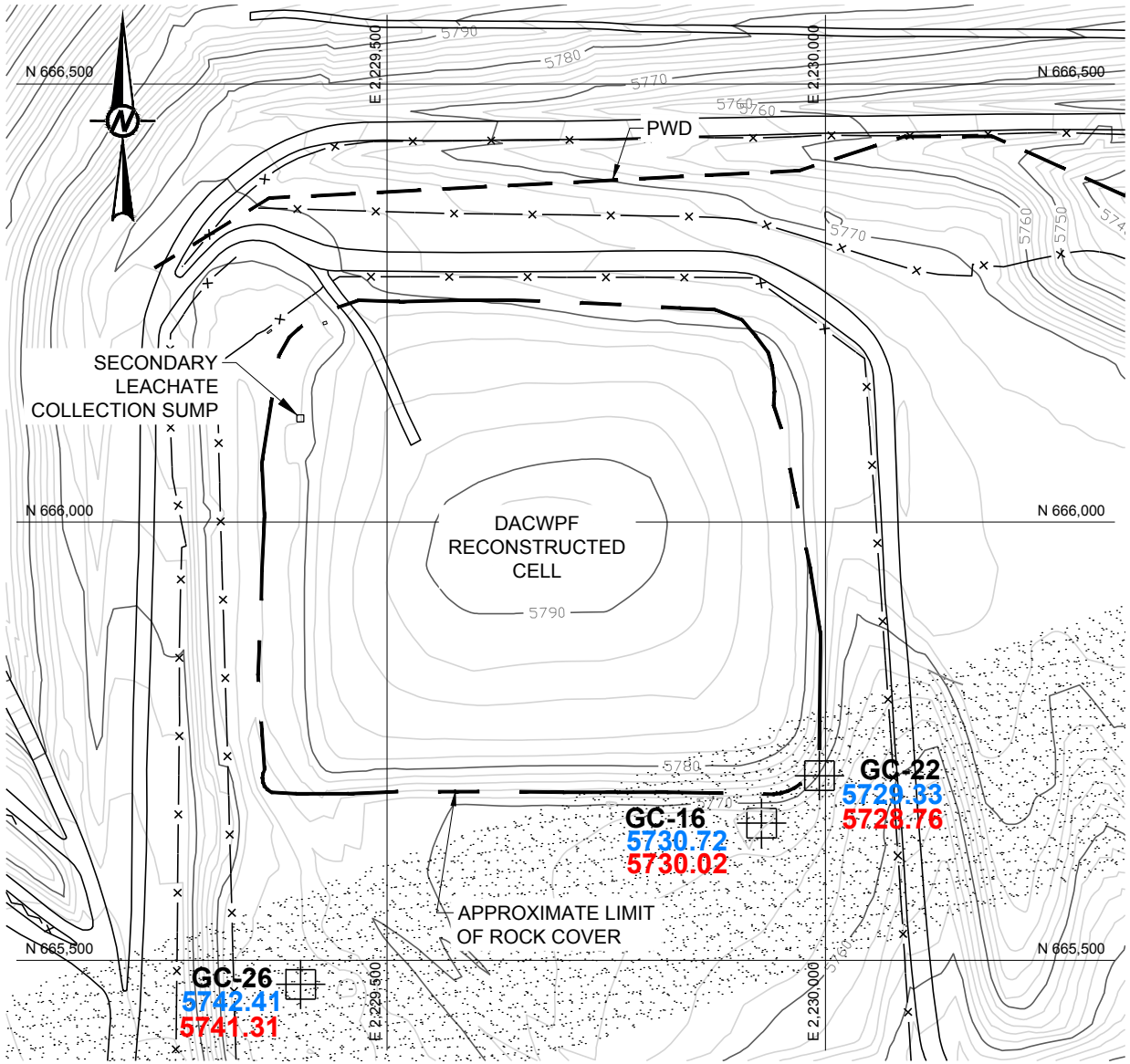
PREPARED	DBS
REVIEWED	MEM
APPROVED	RM

TITLE
GROUNDWATER MONITORING NETWORK AND WATER LEVELS IN UPPER SANDSTONE AND ADJACENT STRATIGRAPHIC UNITS

PROJECT NO. 18111727
REV. A
6



LEGEND

- PIEZOMETER
- PERCHED WATER DRAIN (PWD)
- APPROXIMATE EXTENT OF SILTY SANDSTONE (SM) IN INTERMEDIATE SANDSTONE UNIT

NOTE(S)

1. WATER LEVELS SHOWN IN *BLUE* MEASURED ON 05/09/2018.
2. WATER LEVELS SHOWN IN *RED* MEASURED ON 10/31/2018.
3. ELEVATION GIVEN IN FEET ABOVE MEAN SEA LEVEL.

0 100 200
1" = 200' FEET

CLIENT
WASTE MANAGEMENT OF COLORADO, INC.

PROJECT
DACWPF RECONSTRUCTED CELL FACILITY
PART B POST-CLOSURE PERMIT RENEWAL

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GOLDER

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APPROVED	RM

TITLE
GROUNDWATER MONITORING NETWORK AND WATER LEVELS IN INTERMEDIATE SANDSTONE AND ADJACENT STRATIGRAPHIC UNITS

PROJECT NO. 18111727
REV. A
7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
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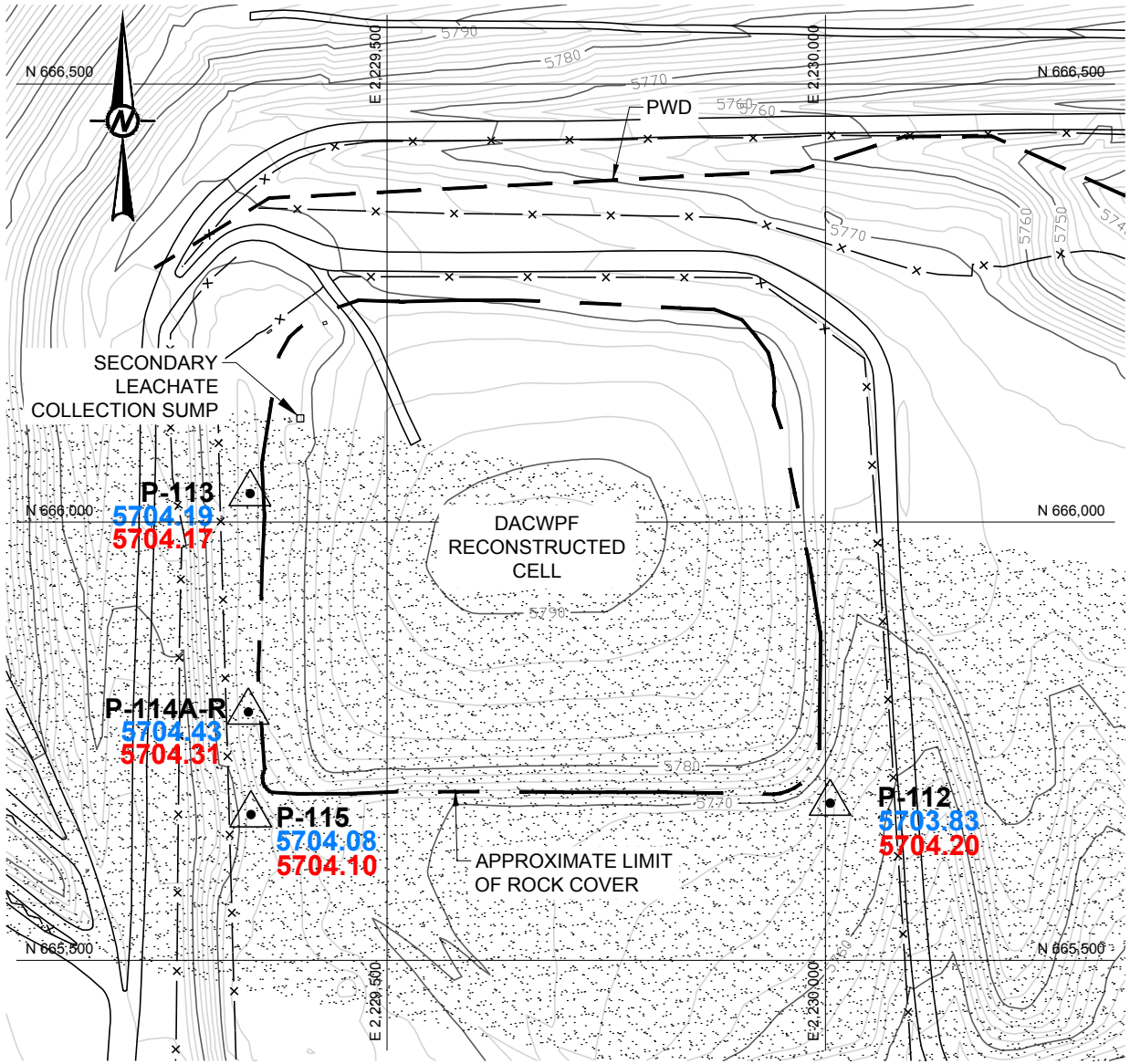

LEGEND

- PIEZOMETER
- PERCHED WATER DRAIN (PWD)
- APPROXIMATE EXTENT OF SILTY SANDSTONE (SM) IN LOWER SANDSTONE UNIT

NOTE(S)

1. WATER LEVELS SHOWN IN *BLUE* MEASURED ON 05/09/2018.
2. WATER LEVELS SHOWN IN *RED* MEASURED ON 10/31/2018.
3. ELEVATION GIVEN IN FEET ABOVE MEAN SEA LEVEL.

0 100 200
1" = 200' FEET

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APPROVED	RM

PROJECT
DACWPF RECONSTRUCTED CELL FACILITY
PART B POST-CLOSURE PERMIT RENEWAL

TITLE
GROUNDWATER MONITORING NETWORK AND WATER LEVELS IN LOWER SANDSTONE AND ADJACENT STRATIGRAPHIC UNITS

PROJECT NO. 18111727
REV. A

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
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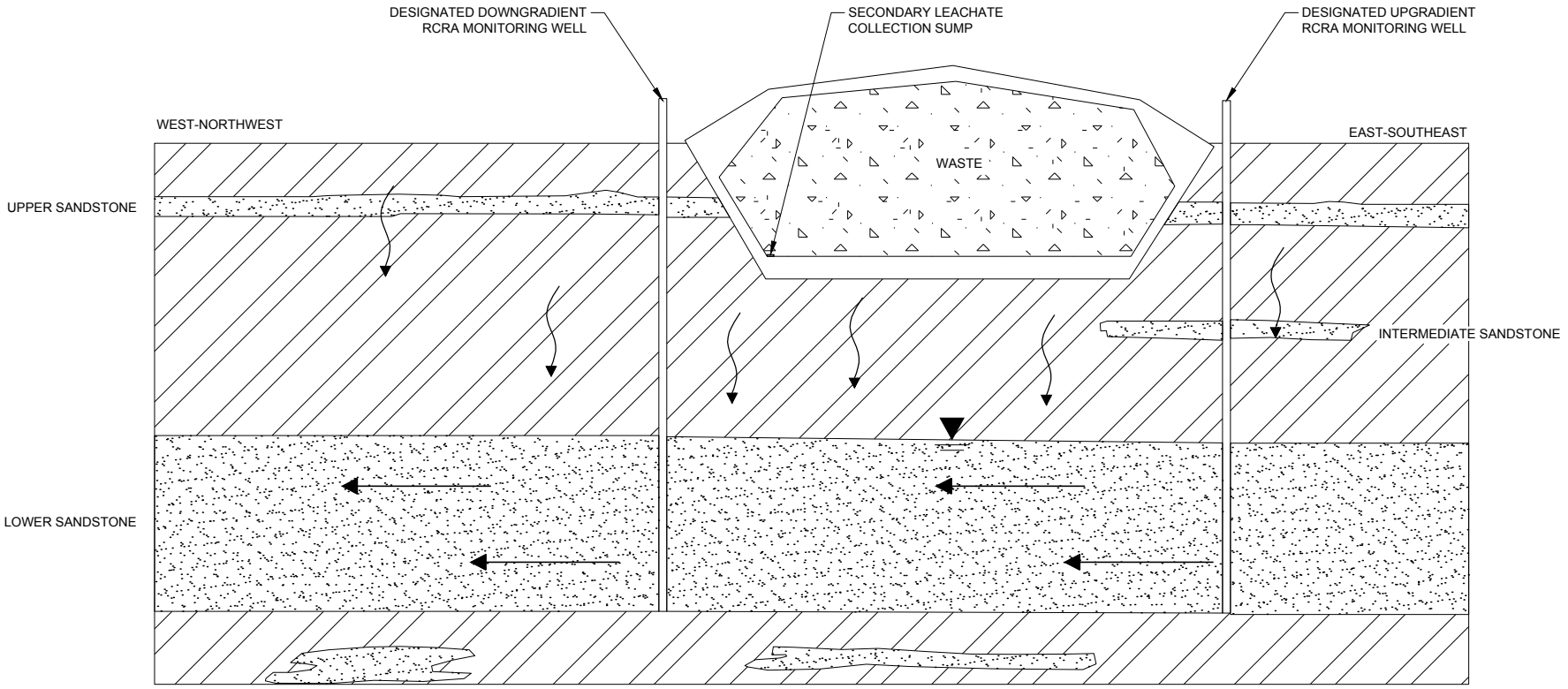

LEGEND

- CLAYSTONE
- SILTY SANDSTONE
- WATER LEVEL
- SATURATED ZONE FLOW DIRECTION
- UNSATURATED ZONE FLOW DIRECTION

NOTE(S)

1. INTERMEDIATE SANDSTONE AS DESCRIBED IN GOLDER (1986) EXISTS ONLY BENEATH THE SOUTH-EASTERN CORNER OF THE RECONSTRUCTED CELL AND IS NOT DEPICTED IN THIS CROSS SECTION.

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APPROVED	RM

PROJECT
DACWPF RECONSTRUCTED CELL FACILITY
PART B POST-CLOSURE PERMIT RENEWAL

TITLE
SCHEMATIC HYDROGEOLOGIC CROSS SECTION

PROJECT NO. 18111727
REV. A

1.0 GENERAL

The purpose of monitoring the upper and intermediate sandstone units is to continue to measure and record groundwater levels in these units in the vicinity of the reconstructed cell. ~~Additionally, the groundwater from these sandstone units will be sampled and analyzed for VOCs and constituents identified in Table F-1 and Table G-1. Constituents in Table G-1 will only be analyzed in the sandstone units if the constituents are detected in secondary leachate sample(s) at levels above their respective action limit.~~ Additional measures will also be conducted if constituents in Table G-1 exceed the action limit for PFOA/PFOS or the detection limit for the other constituents in the secondary sump, reference Section 4.0 below, steps 1 and 2.

TABLE G-1

SECONDARY LEACHATE DETECTION SYSTEM ANALYTES
("Detection Limits" and "Action Limits" are in µg/L = micrograms per liter)

CONSTITUENT	DETECTION LIMIT	ACTION LIMIT
Benzene	5.0	~~5~~10.0
Carbon tetrachloride	1.0	50.0
Chlorobenzene	5.0	~~100~~50
Chloroform	~~3.5~~5.0	~~3.5~~50
1,2 Dichloroethane	1.0	50.0
1,1 Dichloroethene	5.0	~~7.0~~50
Methyl ethyl ketone	100	1,000
Tetrachloroethene	5.0	50.0
Trichloroethene	5.0	50.0
Vinyl Chloride	2.0	~~2.0~~100
Arsenic	10	100
PFOA/PFOS	0.01	~~0.07~~13.6

2.0 MONITORING NETWORK

The monitoring network for the upper and intermediate sandstone units consists of the following:

- Piezometers GC-18, GC-21, and P-107 which are completed in the upper sandstone unit and which are illustrated in Figure 6.
- Piezometers GC-16, GC-22, and GC-26 which are completed in the intermediate sandstone unit and which are illustrated in Figure 7.

These piezometers have been used to date to monitor groundwater levels in the upper and intermediate sandstone units.

3.0 WATER LEVEL MEASUREMENTS AND REPORTING

All groundwater level measurements will be conducted pursuant to ASTM standards or equivalent. The following steps will be performed for each groundwater level measurement event:

Step 1: Inspection. Prior to making the water level measurement, each piezometer will be inspected. Any notable condition of the piezometer structure that could affect the water level measurement will be documented.

Step 2: Static Water Level Measurement. The static water level will be measured and recorded until reproducible results are obtained. The static water level will be measured as the depth of water in the piezometer from the top of the casing and will be recorded to the nearest 0.01 foot.

Water level measurements will continue semi-annually through the post-closure care period. The results of the water level measurements will be recorded for each piezometer and each water level measurement event. The record will include the piezometer identification and date of water level measurement.

All of the groundwater level measurements will be reported on an annual basis along with the water quality data submitted in accordance with Appendix F -- Groundwater Monitoring and Statistical Evaluation Procedures. The groundwater level measurements will also be plotted and submitted with the annual report.

4.0 ~~GROUNDWATER SAMPLING AND ANALYSIS~~ADDITIONAL MEASURES

Pursuant to the conditional delisting, the leachate from the reconstructed cell leachate sumps is to be analyzed at least once a year.

If, in the future, any of the constituents listed in Table G-1 are detected (pursuant to the inspection requirements set out in the Inspection and Maintenance Plan, Appendix C) in the leachate that collects in the reconstructed cell leachate secondary sump at levels above the action limit for PFOA/PFOS or the detection limits of the other constituents listed in Table G-1 (hereinafter “trigger limit”), the Permittee shall proceed as follows:

Step 1: The detection of an analyte above its respective trigger limit listed in Table G-1 shall be confirmed through a review of the QA/QC data to verify that

acceptable field and laboratory data have been generated and recorded and, if appropriate, resampling of the leachate within forty-five (45) days of data receipt. If the detection is not confirmed, the Permittee will continue with groundwater level measurements in accordance with Section 3.0 of this Appendix G. If the detection is confirmed, the Permittee will proceed to the following ~~steps~~Step 2.

Step 2: If detection of an analyte above its respective trigger limit listed in Table G-1 is confirmed in the secondary sump leachate in Step 1, the Permittee will use reasonable efforts to identify and remedy the cause of the detection and will, within sixty (60) days after confirmation submit a report to the CDPHE for review and approval which:

a. Contains the results of the field and laboratory analyses performed;

b. Discusses the analytical results;

c. Summarizes the efforts in identifying and remedying the cause of the detection; and

d. Presents a plan for further work and monitoring (as and if necessary) together with any necessary permit modification requests for implementing such further work, to further identify and remedy the cause of the detection and/or to determine if the effectiveness or integrity of the reconstructed cell have been compromised.

~~Step 3: If detection of any VOC or PFOA/PFOS analyte above the action limit listed in Table G-1 is confirmed in the secondary sump leachate in Step 1, the Permittee will, within forty-five (45) days after confirmation of the detection, initiate the field activities for the installation of three groundwater monitoring wells in the upper sandstone unit and three groundwater monitoring wells in the intermediate sandstone unit at locations as generally shown in Figure 3 and, upon completion of these groundwater monitoring wells, the Permittee will sample them in accordance with the procedures set forth in Sections 2.4 and 2.6 of Appendix F for the following parameters:~~

~~(i) For detection of any VOC, the samples will be analyzed for the VOC constituents listed in Table F-1 of Appendix F in accordance with the laboratory analytical procedures listed in Section 2.5 of Appendix F. The Permittee will also review the QA/QC data to verify that acceptable field and laboratory data have been generated and recorded and, if appropriate, resample any wells found to have unacceptable data.~~

~~(ii) For detection of any PFOA/PFOS, the samples will be analyzed for PFOA/PFOS in accordance with the USEPA Method 537, Modified analytical procedures until EPA Method 8328 is finalized, and the Permittee will also review the QA/QC data to verify that acceptable field and laboratory data have been generated and recorded and, if appropriate, resample any wells found to have unacceptable data.~~

If detection of arsenic above the action limit in Table G-1 is confirmed in the secondary leachate sump, the Permittee will, within forty-five (45) days after confirmation of the detection, either:

a. Submit a report to the CDPHE demonstrating that the arsenic detection above the action limit in Table G-1 was caused by a source other than the waste in the reconstructed cell; or

b. Initiate the field activities for the installation of three groundwater monitoring wells in the upper sandstone unit and three ground monitoring wells in the intermediate sandstone at locations as generally shown in Figure 3. Upon completion of these groundwater monitoring wells, the Permittee will sample them in accordance with the procedures set forth in Sections 2.4 and 2.6 of Appendix F. The samples will be analyzed for arsenic in accordance with the laboratory analytical procedures listed in Section 2.5 of Appendix F and the Permittee will also review the QA/QC data to verify that acceptable field and laboratory data have been gathered and recorded and, if appropriate, resample any wells found to have unacceptable data.

Step 4: The Permittee will, within forty-five (45) days after receipt of the final laboratory results for the sampling event described in Step 3, submit a report to the CDPHE which:

Step 5: Outlines the activities performed;

Step 6: Contains all field information relevant to the installation of the new groundwater monitoring wells in the upper and intermediate sandstone units;

Step 7: Contains the results of the field and laboratory analyses performed including the information listed in Section 2.9 of Appendix F;

Step 8: Discusses the analytical results; and

Presents a plan for further work (if necessary); together with any necessary permit modification requests for implementing such further work, to determine if the effectiveness and integrity of the reconstructed cell has been compromised.